LIPPINCOTT'S
EDUCATIONAL GUIDES
EDITED BY W. F. RUSSELL, Ph. D.

BRIGHTNESS AND DULLNESS IN CHILDREN

HERBERT WOODROW, Ph.D.

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DEAN, COLLEGE OF EDUCATION, UNIVERSITY OF IOWA

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BRIGHTNESS AND DULLNESS IN CHILDREN

BY
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ILLUSTRATED

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BRIGHTNESS AND DULLNESS IN CHILDREN

CHAPTER I

INTRODUCTION

The day before his fifth birthday, Francis Galton wrote the following letter[1] to his sister:

> MY DEAR ADÈLE:
>
> I am 4 years old and I can read any English book. I can say all the Latin Substantives and Adjectives and active verbs besides 52 lines of Latin poetry. I can cast up any sum in addition and can multiply by 2, 3, 4, 5, 6, 7, 8, [9], 10, [11].
>
> I can also say the pence table. I read French a little and I know the clock.
>
> FRANCIS GALTON,
> Febuary 15, 1827.

The only misspelling is in the word February. The numbers 9 and 11 are bracketed because one had been scratched out with a knife, and the other was covered by a bit of paper pasted over it.

By the age of six, Galton was conversant with the Iliad and the Odyssey. At six and seven, he busied himself with collecting insects and minerals, which he is said to have classified and studied in more than a childish fashion. The following well-worded note proves that at the age of ten he was absorbed in religious questions:

---

[1] From vol. i of Karl Pearson's "Life, Letters and Labors of Galton." Quoted by Terman in the *American Journal of Psychology*, vol. xviii, 1917, p. 210.

December 30, 1832.

My dearest Papa:

It is now my pleasure to disclose the most ardent wishes of my heart, which are to extract out of my boundless wealth in compound, money sufficient to make this addition to my unequaled library:

The Hebrew Commonwealth by John	9
A Pastor Advice	2
Hornne's commentaries on the Psalms	4
Paley's Evidence on Christianity	2
Jones Biblical Cyclopedia	10
	27

Notwithstanding his wonderful precociousness, this noted English scientist accomplished his best work at an advanced age. *Hereditary Genius* was published in his fiftieth year; *Natural Inheritance* in his sixty-eighth.

Galton is only one among a vast number of men of genius who are known to have displayed exceptional ability in childhood. The majority of poets and musicians show their genius at a very early age. Tasso was famous at the age of eight and Southey wrote dramas before that age; at the age of three, Mozart took piano lessons; at four, he played minuets and composed short pieces; and at five, he performed in public.

In the field of science and philosophy, among those who were famous in their youth are Lord Bacon, Kant, Locke, Berkeley, Descartes, Spinoza, and Lord Macaulay. Macaulay read incessantly at the age of three. At seven, he began *A Compendium of Universal History,* and at eight he wrote *A Treatise to Convert the Natives of Malabar to Christianity.* All of these men lived to a fairly advanced age and continued their creative work throughout the greater part of their lives.

I have referred particularly to Galton merely because he belongs to that group of geniuses of whom it is sometimes alleged that they show no signs of exceptional ability until late in life. Clearly in Galton's case, the idea that genius develops slowly is based on ignorance: Galton was a genius even in his boyhood. Whether with more abundant information we should find all men of genius to have been exceptional children, it is impossible to say. On the other hand, of those placed at the opposite extreme of intelligence, the feeble-minded, it may be said with assurance that their careers as adults are faithfully foreshadowed by the performances of their childhood, even of their very early childhood. And since our interest at present is in differences in intelligence which exist in children, it is well worth our while to consider the contrast between the early record of Francis Galton and the following one of a girl named Abbie, a case typical of high-grade feeble-mindedness of the sort that is not uncommon in the special classes of our city schools.

Admitted to the New Jersey Training School for Feeble-Minded Boys and Girls in 1900, at the age of eleven, Abbie was small for her age, left-handed, and awkward. She always put the *same foot* forward when going up or down stairs; she knew her letters but could not read; she could count to ten; she knew some color and form; and she sang a number of hymns that she had learned at home. Her sight and hearing were normal, and she was fond of play.[2] Among Abbie's more unfavorable characteristics were a bad memory and a poor power of imitation. She was gluttonous, untidy, untruthful, sly and profane.

Three months after her admission she could thread a needle and sew on buttons, could dust and rub floors a little, had learned to read *A man ran* and *I see a man* (sometimes), counted to twenty, and, with help, could do such number work as this: $\begin{array}{r}1\\ \underline{1}\end{array}$ $\begin{array}{r}2\\ \underline{1}\end{array}$ $\begin{array}{r}3\\ \underline{1}\end{array}$.

---

[2] *The Training School,* vol. vii, 1910, p. 182.

For ten years she went to school. "For ten years," runs the report, "her teachers struggled heroically to give her the mastery of *something*. Little less than marvelous is the optimism and faithfulness of those teachers! We see them struggling on month after month, not in that perfunctory way born of discouragement or conscious failure, but with that courage and cheerfulness which comes from grasping at every straw of encouragement, of progress, of fancied improvement. Had these teachers become discouraged, we would have to admit that perhaps the result might be due to that fact. But there is no sign of giving up in all these years. Within the last few months, however, there has appeared the feeling that Abbie has reached her limit. She will be twenty-two years old before long.

"To-day she is still small for her age. She can braid corn-husks a little; can make a bed; can iron an apron; cannot count the cost of three one-cent stamps and three two-cent stamps, with the stamps before her; cannot repeat five figures or a sentence of fifteen words; defines only in terms of use; can read a few sentences, spell a few words and write about twenty-five words from memory; knows the days of the week, but not the months of the year; and does not know how many fingers she has on both hands."

Francis Galton and little Abbie represent opposite poles of human intelligence; they typify the extremes and between them are any number of variations. The differences existing between individuals in regard to common sense, mental ability and character are enormous. Obviously, they are of the utmost importance in determining the constitution of society and the aims of education. These differences come most clearly to view in the successes and failures of adult life. What is opportunity for one man is discouragement for another; as one climbs to eminence, another, starting with equal opportunities, treads a path that leads him to the poor-house. The struggle of life constitutes the test, a test which some pass gloriously and others utterly fail. Adult life, however, merely emphasizes the existence of individual differences in endowment; it does not create them. For the most part, these differences, determining factors in the careers of men and women, are present in early childhood. In almost any American school the children display nearly every degree of intelligence between the brilliant Francis Galton and the feeble-minded Abbie.

Psychological and pedagogical investigations conducted during the last decade have clearly demonstrated the fact that children of the same age and the same amount of schooling vary from one to five years or more in mental capacity as well as in their school grade, and that the number of children who differ widely from what may be termed the normal is very much greater than has been generally supposed. Of course the factors which determine the rank a child takes, whether in school or out of school, are innumerable. One child may enjoy better health than another, be better nourished and less easily fatigued, or have fewer physical defects. One may study harder or with more interest and concentration of attention than another. Home environment is of great importance. A child reared in a slum, by ignorant or wicked parents incapable of training him properly, cannot fairly compete with one who is influenced from the first by culture and sane discipline. Again, the quality of a child's companions is a crucial element. Differences in intelligence may depend upon ability or disability in some particular mental function, such as the capacity for visualization or for rote memory. Countless circumstances and conditions affect a child's success in the innumerable performances which make up his life; but the most comprehensive and fundamental of them all, to which the tests must inevitably return, is, finally, his innate brightness or dullness.

Now brightness and dullness refer merely to a child's comparative intelligence. A bright child is one with more than ordinary intelligence and a dull child one with less than ordinary intelligence. Evidently, then, if we wish to act wisely in guiding the development of our children, we must understand the nature of intelligence, the factors affecting it, and the consideration that must be given it in the choice of educational aims and methods. These subjects are discussed in the following pages. Our knowledge of them has greatly advanced since 1908, when Binet and Simon perfected their famous method of measuring intelligence. This information is practically new, and is constantly and rapidly increasing, but it already constitutes one of the most important chapters of modern science.

Although, as I have said, a child's success in school is not determined solely by his intelligence, but depends on a great many other factors, every one of these stands in some relationship to intelligence. Consequently they must be included in any thorough study of brightness and dullness. One cannot understand the nature of intelligence without studying its relation to health, to the development of the brain and the rest of the body, its relation to the senses and to the various mental processes such as attention, memory and judgment and to defects in these, the degree to which it is modifiable by learning and by the environment and, on the other hand, the degree to which it is fixed by heredity. It is evident that the subject of intelligence is a broad one, as broad as the whole field of psychology, and that it touches upon other sciences as well. It deals with fundamental problems to be met with in all branches of human activity.

Heretofore the lower degrees of intelligence, dullness and feeble-mindedness, have forced themselves most strongly upon the attention of investigators. Because more is known about the lower end of the scale than the higher, I have purposely emphasized, in this discussion, the higher. To be sure, the problem of feeble-mindedness is enormously important. "Feeble-mindedness," wrote Amos Butler, " produces more pauperism, degeneracy and crime than any other one force. It touches every form of charitable activity. It is felt in every part of our land. It affects in some way all our people." [3] But facts concerning feeble-mindedness constitute only a small part of our knowledge about intelligence. We are beginning nowadays to study the exceptionally bright child as well as the dull one, realizing that, if it is worth while to discover the best training for a feeble-minded girl like Abbie, it is many times worth while to seek out adequate preparation for the future leaders in literature and art, science, business, and government. But in dealing with bright children or with dull, there are certain laws and relationships which are fundamental, and which hold for all degrees of intelligence. There has grown up a science of general intelligence. This book is intended to serve as an introduction to that science.

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[3] "The Burden of Feeble-Mindedness." *Proceedings of the 34th Conference of Charities and Corrections,* 1907, p. 10.

By the science of intelligence I do not mean simply the art of applying a modern scale for the measurement of intelligence. To apply these scales is the task of the specially trained expert. The scales themselves are still in the experimental stage, and so are constantly being modified. It requires a prohibitive amount of time and study to keep abreast with the latest developments, to say nothing of the time necessary to give the tests. Consequently no one but a specialist has the opportunity and skill to be a good intelligence tester. However, no matter how successfully the tests of intelligence are conducted, the immediate results in themselves have little value. They by no means constitute an adequate mental diagnosis. They must be interpreted in connection with other data before any definite conclusions can be drawn. The intelligence tester needs, in addition to his technical skill, a knowledge of intelligence in all its aspects and relations—a very broad and thorough knowledge. And to the average worker with children, to the educator, whether administrator or teacher, just this broader knowledge is of infinite value. It is with this material that the following pages are concerned; they do not comprise a manual of intelligence testing. Some account, it is true, is given of the methods for measuring intelligence. This is done, however, for the light that a knowledge of these methods throws upon the meaning of intelligence, and upon the many important conclusions to which their use has led.

The topic of intelligence is naturally of the utmost concern to the educator, because education deals primarily with the development or training of intelligence. The teacher must grapple with problems of the development of intelligence, and of individual differences in intelligence, not occasionally and incidentally, but constantly. These are the very gist of her work. Without a thorough understanding of the modern investigations along this line, and their significance, it is impossible for the teacher to know what she should aim to do or what methods she should employ in the accomplishment of her aims.

The teacher of to-day needs a knowledge of the modern psychology of intelligence. She must know when it is desirable to try to bring a backward pupil up to grade, and when it is not, and why it usually is not. She should realize that the exceptionally bright child who seldom troubles her may be her greatest problem. She should understand the sources of the errors teachers often make in their estimates of brightness and dullness, such, for instance, as the failure to take properly into account differences in age. She should be familiar with the concept of mental age and with the method of classifying children as superior, dull, or normal by its aid more accurately than in any other manner. The teacher should know that intelligence has a physical basis, and should understand the relation of intelligence to the brain and to physical defects. This relation places heavy responsibilities upon her. Further, she ought to understand the part played by the various mental processes in the make-up of intelligence, and the interrelationship and organization of these processes. She should comprehend the relationship between mental ability and success and failure in school work, in order to determine upon the proper treatment of over-age pupils, and in order to value the great problem of preventing children from dropping out of school before they have received the education that is their right. She must know that innate brightness and dullness can be recognized at an early age, and that they demand recognition as fundamental factors in the determination both of the general school organization and of educational methods.

Clearly, the science of education depends upon, and finds its surest foundation in, the science of intelligence.

CHAPTER II

THE MEASUREMENT OF INTELLIGENCE

THE successful measurement of intelligence, first accomplished by the method of Binet and Simon, is perhaps the most brilliant achievement of modern psychology. It supplied an imperative need long felt by all discerning persons engaged in work with children. The science of psychology has been vitalized and rejuvenated by this achievement, which, in its far-reaching and ever-growing developments in the fields of psychology and education, has exceeded the most sanguine expectations of those men of clear vision who labored towards its culmination.

Pioneer Studies in the Measurement of Intelligence.—Work earlier than that of Binet, and, indeed, much of the earlier work of Binet himself, was directed not so much towards the measurement of intelligence as a whole as towards the development of tests for measuring various elementary features of human capacity. The great pioneer in this sort of work was Francis Galton, who, in 1883, published an elaborate account of individual and racial differences.[1] The object of his tests and measurements, he described as follows: "It is to obtain a general knowledge of the capacities of a man by sinking shafts, as it were, at a few critical points. In order to ascertain the best points for the purpose, the set of measures should be compared with an independent estimate of the man's powers. We may thus learn which of the measurements are the most instructive."[2]

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[1] "Inquiries into Human Faculty."

Galton gathered much of his data by rather crude methods, such as mere casual observation. In some cases, however, he followed quasi-scientific procedures. He studied differences in mental imagery by elaborate questionnaires; the ability to make discriminations in weight, he tested by careful experiment; and for determining sensitivity to high pitches, and the limit at which pitches become too high to be audible, he devised a kind of whistle. One of these, he tells us, he had set into the end of his walking-stick, with a bit of rubber tubing concealed under the handle. A sudden squeeze of the tubing forced a little air into the whistle and caused it to sound. On his walks through zoological gardens, he amused himself by sounding this apparatus as near to the ears of the animals, as he safely could. If the animals pricked up their ears, he concluded that they had heard the whistle; if they did not, that the tone was inaudible.

Galton was followed by a large number of investigators, who, while perfecting the precision of mental tests and increasing their number, made observations regarding their applicability to various practical problems. In Germany, Kraepelin inaugurated studies of the differences between the mentally normal and the insane. In America, Cattell devised a set of tests which for a number of years were given to freshmen entering Columbia University. These tests were designed to measure such capacities as the following: Strength of grip, or the greatest possible squeeze of the hand; sensory discrimination by the skin, indicated by the distance that must separate two compass points in order that they may be felt as two; the sense of pain, measured by the amount of pressure on the ball of the hand required to produce a painful sensation; the ability to discriminate weight, marked by the least difference noticeable; reaction time, the time elapsing before a stimulus, *e.g.,* a loud sound, calls forth a movement made in response to it by the finger; visual space perception, determined by the ability to bisect a 50 cm. line; time estimation, shown in the ability to reproduce an interval of 10 seconds by taps made on the table; and memory, manifested by the number of letters that can be repeated correctly after one hearing.[3]

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[2] Remarks, following an article by Cattell, on "Mental Tests and Measurements," in *Mind,* vol. xv, 1890, p. 380.

As measures of ability, Cattell's tests were chiefly negative in value.[4] Other tests, however, which were directed primarily to the study of children, were somewhat more successful. Gilbert, for example, established by a number of tests, norms of performance for school-children of all ages from 6 to 17. Besides finding an increase in ability with advance in years, he found some of his tests to correlate with the brightness of the children as estimated by their teachers. "The curves for reaction time gave the most positive results, showing that the brighter the child the more quickly he is able to act." [5] These tentative beginnings continued until finally it appeared possible to establish norms whereby a child could be readily classified for pedagogical purposes.[6]

The work of American investigators was criticized by

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[3] "Mental Tests and Measurements." *Mind,* vol. xv, pp. 374-377.

[4] See Wissler, "Correlation of Mental and Physical Tests." *Psychological Review Monograph Supplements,* vol. iii, 1901, No. 16.

[5] "Researches on the Mental and Physical Development of School Children." *Studies from the Yale Psychological Laboratory,* vol. ii, 1894, p. 94.

[6] See Kelley, "Psycho-Physical Tests of Normal and Abnormal Children." *Psychological Review,* vol. x, 1903, p. 371.

Binet and Henri,[7] the distinguished French psychologists, on the ground that the tests employed measured mental processes which were too simple—which did not sufficiently involve the "superior mental faculties." They accordingly proceeded to devise a large number of tests, which, although simple in application, involved more complex mental activity. Instead of measuring the ability to distinguish slightly different weights or colors, they sought to obtain an appreciation of such powers as those of judgment, synthesis, imagination and æsthetic appreciation; often the mental functions tested could not be exactly analyzed; it could only be said that they were complex.

The Binet-Simon Measuring Scale.—The Binet-Simon scale represents a crystallization of the experience acquired through many years of experimentation. For years before the perfection of this scale, Binet had studied the value of mental and physical tests. He had covered an extensive field, including measurements of the head, height and weight, and tests of perception, memory and attention. He had for years been experimenting among the children in the schools of Paris, until he had acquired an expert knowledge of child psychology.

The practical necessity of devising some means for the measurement of intelligence was brought home to him with great force when, in 1904, the French Minister of Public Instruction made him a member of a commission appointed for the purpose of organizing classes for subnormal children in the public schools of Paris. How were subnormal children to be positively distinguished? Very hazy notions surrounded the matter, and it was important that the selection of children for special classes should not be left to the uncertainties of personal opinion. It was under the incentive of this pressing and practical difficulty that Binet, in collaboration with Dr. Simon, produced the brilliant synthesis known as the Binet-Simon measuring scale of intelligence. This scale, in its earliest guise, was published in 1905 and in its perfected form in 1908.

---

[7] "La psychologie individuelle." *L'Année psychologique,* vol. ii, 1895, p. 426.

The Binet-Simon scale comprises a large number of intelligence tests arranged in a series of increasing difficulty. The tests require the answering of brief, direct questions and the performance of simple tasks, all bearing upon matters of every-day life. They manifest great variety and demand many different mental processes, as the following list shows. Subjects are asked to execute simple orders; to name familiar objects; to repeat short series of digits and short sentences; to compare lengths, and weights; to count, naming pieces of money, and making change; to define familiar, concrete terms and abstract terms; to point out similarities in the meaning of two words; to point out differences; to tell what they see in a complex picture; to copy geometrical figures or reproduce them from memory; to tell what ought to be done in various situations; to put together the words of a dissected sentence so that they make sense; and to recognize absurdities.

Some authorities are of the opinion that the success of the Binet and Simon tests is due to their preoccupation with the higher and more complex mental functions. Although there is some truth in this contention, many of Binet's tests are exceedingly simple; as simple as any of the older tests. Taken individually, Binet's tests have not been proved superior to, nor greatly different from the older tests. Indeed, some of the Binet tests, such as those calling for weight discrimination and memory feats, are survivals of the oldest psychological tests in existence. The real secret of Binet's success lies in the fact that, after long years of experimenting with separate tests, he finally decided to use a large number of tests in combination. Intelligence, he decided, is too complex to be measured by any one test; but by using in combination five or six quite dissimilar tests, he found immediately that he could obtain significant results.

While the success of the Binet and Simon tests is due fundamentally to the use of a number of tests in combination, the world-wide popularity they so rapidly attained must be attributed largely to their arrangement by ages. They are all classified according to the age at which the average, or normal, child can pass them. Thus, there are five tests for four-year-old children, five others for children of five years, five, still different, for children of six years, and so on. The idea is simply that at each age the ordinary, normal child can do certain things which he could not do at an earlier age; and that by arranging a system of tests to test ability to do these things, one can determine to what age of a normal child the ability of any tested child corresponds. The age of the normal child whose ability is equalled by the tested child is said to be the mental age of the latter. It is thus an easy matter to understand just what the Binet tests do: they measure intelligence in terms of mental age.

The desirability of obtaining an estimate of intelligence in terms of mental age had long been recognized.[8]

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[8] See Rogers, "The Classification of the Feeble-Minded Based on Mental Age." Reprinted from the *Bulletin of the American Academy of Medicine,* vol. xiii, 1912, No. 3.

As far back as 1828, Esquirol, the first writer clearly to define the term idiocy, called attention to the fact that an idiot was incapable of acquiring the knowledge of other persons *of his own age* placed in similar conditions with himself.[9]

Duncan and Millard, in 1866, plainly thought in terms of mental age, when they wrote, concerning the various classes of feeble-minded, "It is a very striking method of showing the mental deficiency of a member of any one of these classes to compare its mental gifts with those of children of perfect mind at younger ages."[10]

In the same vein, we find Down, in 1887, discussing as follows the classification of backward and feeble-minded children: "In any given case we have to ask ourselves, can we in imagination put back the age two or more years and arrive thus at a time perfectly consistent with the mental condition of our patient? If he be a backward child, we shall have no difficulty in saying what period of life would be in harmony with his state. If, however, he be an idiot, there is no amount of imaginary antedated age to which the present condition of the child corresponds."[11]

The concept of mental age is clearly implied, though not definitely formulated, in these passages. *Mental age* means a certain degree or amount of intelligence. A year's growth in mental age is a unit, although one which changes with age, for the measurement of intelligence. Each mental age stands for the degree of intelligence possessed by the normal child of the corresponding chronological age. To say that a child has a given mental age means simply that he behaves in the manner of the average, or normal, child of that age—that he is capable of doing the same things. Thus, if a child ten years of age can do only the same things that a normal eight-year-old child can do, if he passes only the same tests, then, in spite of the fact that his chronological age is ten, his mental age is only eight; he is two years mentally retarded. On the other hand, if a child of ten is found to be capable of the same mental performances as the average twelve-year-old child, we say that his mental age is twelve and that he is two years mentally advanced.

---

[9] "Observations pour servir à l'histoire de l'idiotie." *Les maladies mentales,* Paris, 1828.

[10] "A Manual for the Classification, Training, and Education of the Feeble-Minded, Imbecile, and Idiotic," p. 13.

[11] "Mental Affections of Childhood and Youth," 1887.

Binet and Simon adopted this concept of mental age, and arranged their tests in such a manner as to measure it. In order to determine what normal children of each chronological age could do, they tried out their assortment of tests on children of all ages and thus settled upon those which could be passed by a majority of children of each age. In this way, they secured certain tests which six-year-old children could pass, but which most five-year-olds could not; others which most seven-year-olds could pass, but most six-year-olds could not, and so on. It is such a series of tests, classified in sets according to the age at which normal children ought to pass them, that constitutes the Binet-Simon scale for the measurement of intelligence. It extends from the age of three to the age of fifteen.

To illustrate the arrangement of these test-performances by years, I may cite the original list of accomplishments, in an abbreviated form, for children of the ages four to twelve.[12]

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[12] Goddard, "The Binet-Simon Measuring Scale for Intelligence." *The Training School,* vol. vi, 1910, pp. 146–154.

Mental Age Four Years

1. Gives sex of self.
2. Names familiar objects (key, knife and penny).
3. Repeats correctly three digits, *e.g.*, "7–2–9."
4. Tells which of two lines is the longer (5 cms. and 6 cms.).

Mental Age Five Years

1. Correctly compares 3 and 12 grams and 6 and 15 grams.
2. Copies a square of 3 or 4 centimeters well enough to recognize it as a square.
3. Repeats 10 syllables, *e.g.*, "His name is John. He is a very good boy."
4. Counts four pennies placed in a row.
5. Re-forms a visiting card from the two pieces made by cutting one diagonally.

Mental Age Six Years

1. Tells whether it is morning or afternoon.
2. Defines by use at least three of the following: *fork, table, chair, horse, mama.*

   "At four years, half the children define by 'use': it increases a little at five, and at six practically all define this way. Not before nine do the majority give the definitions that are 'better than by use.'"
3. Executes three simple commissions given at once.
4. Indicates right hand and left ear.
5. Chooses the prettier of two heads, one pretty, the other very ugly, when they are shown in pairs.

Mental Age Seven Years

1. Counts thirteen pennies placed in a row.
2. Tells what he sees in pictures. Describes instead of simply naming things.
3. Tells what is lacking when shown pictures of a head lacking an eye, a mouth or a nose, or of a head and body lacking arms.
4. Copies a diamond.
5. Names promptly four colors—red, blue, green and yellow.

Mental Age Eight Years

1. Tells difference between a butterfly and a fly; between wood and glass; between paper and pasteboard.
2. Counts backwards from 20 to 1, in 20 seconds.
3. Names days of the week in 10 seconds.
4. Tells how much they are worth, when shown three one-cent and three two-cent stamps.
5. Repeats correctly five digits, *e.g.*, "4–7–3–9–5."

MENTAL AGE NINE YEARS

1. Makes change—9 cents out of 25.
2. Gives definitions better than by use.
3. Names the day of the week, the month, the day of the month, and the year.
4. Recites the months of the year in 15 seconds.
5. Arranges in correct order a series of weights of 6, 9, 12, 15 and 18 grams.

MENTAL AGE TEN YEARS

1. Names nine different pieces of money.
2. Draws two simple geometrical designs from memory.
3. Repeats six digits.
4. Answers intelligently simple problem questions, *e.g.*, "What ought one to do before undertaking something important?"
5. Uses three words, as New York, money and river, in one sentence.

MENTAL AGE ELEVEN YEARS

1. Detects the nonsense in absurd statements.[13]
2. Uses three words in one sentence (given also at age ten).
3. Gives sixty words in three minutes.
4. Finds three words in one minute which rhyme with words like day, mill or spring.
5. Forms a sentence in one minute out of ten printed words in disconnected order, as the following: started—the—for—an—early—hour—we—country—at—.

MENTAL AGE TWELVE YEARS

1. Repeats correctly seven digits, once in three trials.
2. Defines charity, justice, goodness.
3. Repeats a sentence of twenty-six syllables.
4. Resists suggestion.
5. Solves problems of facts. (*a*) "A person who was walking in the forest of Fontainebleau suddenly stopped much frightened and hastened to the nearest police and reported that he had seen hanging from the limb of a tree a—what?" (*b*) "My neighbor has been having strange visitors. He has received one after the other a physician, a lawyer and a clergyman. What has happened at the house of my neighbor?"

It must be clearly understood that not all children of a given mental age will pass all the tests for that age. Owing to the unequal degree of development of the different mental functions, it nearly always happens that a child who fails on one or two of the tests of one age can pass some of the tests for the next higher age. Consequently the rule for determining the mental age of a child is to take the highest mental age for which all tests are passed *plus* one-fifth of a year for each additional test.

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[13] See Chapter X, p. 190.

Evidence of the Accuracy of the Revisions of the Binet-Simon Scale.—The Binet tests were promptly introduced into America, chiefly through the translation and revision of Dr. Goddard, who used the tests extensively and gave them an enthusiastic endorsement. The published data clearly indicated, however, that the tests were capable of improvement. At the lower ages they showed far more children advanced than retarded, whereas at the upper ages they rated the majority of children as retarded. Plainly, they were too easy at the lower ages and too hard at the upper ages.

No sooner were these imperfections recognized than psychologists in various parts of the country undertook their elimination. Elaborate experimental work was carried on, and the standards to which these tests had to conform in order to be entirely reliable, were taken under consideration. As the criteria of reliability were established, the tests were revised to conform to them.[14] Some of the tests were shifted to different ages and others replaced by better ones. The amount of painstaking, scientific work done upon these tests was enormous. As a result, the Binet tests, in their latest form, have an unquestioned validity. An examination of the evidence makes this clear. There is scarcely an important criterion of accuracy with which the tests do not comply.

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[14] Kuhlmann, "A Revision of the Binet-Simon System for Measuring the Intelligence of Children," *Journal of Psycho-Asthenics, Monograph Supplements,* vol. i, No. 1, 1912, and "A Handbook of Mental Tests," 1922; Yerkes, Bridges and Hardwick, "A Point Scale for Measuring Mental Ability," 1915; and Terman, "The Measurement of Intelligence," 1916, and "The Stanford Revision and Extension of the Binet-Simon Scale for Measuring Intelligence," 1917.

The accuracy of the tests is to be judged in two ways: First, by the results with groups of children, and, second, by results with individual children. Groups of children who are all of the same age offer the advantage that, when they are large, it is safe to assume that the older the group the greater the average intelligence. We can be sure that we have ranked the age groups according to intelligence when we have ranked them according to age. We thus obtain through the use of groups a natural scale of intelligence by which to test our methods before applying them to individual children.

The first problem, then, was to shape the scale for measuring mental age so that it was reliable with groups. By definition, mental age should equal chronological age in the case of the average or median child. The median child is one who stands at the middle of a large group of children of his own age. Thus, after we have measured the mental age of a large group, all of the same chronological age, and arranged the mental ages in a column from highest to lowest, if we count down from the top to the middle of the column, we should find at the middle a mental age exactly equal to the chronological age of the group. That is, the middle or *median* mental age of a group of children who are equally old in years should agree with the chronological age of the group. The agreement should be exact and must be established for all ages. After many revisions, this agreement has been secured; so that now a user of the scale may be confident that with a large group of six-year-old children the median mental age obtained will be six, and that with a large group of seven-year-old children, it will be seven, etc.

It is very important to note the distribution of children's mental ages about the median. Most children have a mental age very close to the median. The others are usually one or two years above or below it, and taper off in numbers gradually and symmetrically. This characteristic distribution is illustrated fairly well by the following results obtained with one hundred Minneapolis school children, between ten and eleven years of age, chronologically.

Mental Ages of One Hundred Ten-Year-Old Children

Mental Age	Number of Children
From 7.5 through 8.0	1
From 8.0 through 8.5	0
From 8.5 through 9.0	3
From 9.0 through 9.5	11
From 9.5 through 10.0	19
From 10.0 through 10.5	30
From 10.5 through 11.0	17
From 11.0 through 11.5	9
From 11.5 through 12.0	6
From 12.0 through 12.5	1
From 12.5 through 13.0	3

The average chronological age of the group is ten years and five months, and the average mental age very nearly the same, namely, ten years and four months. The boys and girls in the group average about the same in chronological age, but the girls are ahead of the boys in mental age. The average mental age of the fifty-three girls is ten years and six months; that of the forty-seven boys is only ten years and one month.

We may chart the distribution of these one hundred children along the scale of mental age, by constructing a figure in which the mental ages are represented along its base line and the number of children having each of the mental ages by its height. We thus obtain the accompanying figure (Fig. 1).

The irregularity in Fig. 1 is due to the fact that it is based on a comparatively small number of children and that it does not take into account fractions of less than one-half year in mental age. With a very large group, and with measurements in terms of very small fractions of a year, we should get a smooth curve, resembling what is known as a normal distribution curve. This curve would be smooth and symmetrical, fitting, as well as possible, the outlines of Figure No. 1. It would show, even better than the figure, that the number of children above the median mental age is equal to the number below it; and that as the distance above or below increases the number of children decreases. It is sometimes considered a sign of accuracy when the mental ages of a large group of children to whom the tests are applied turn out

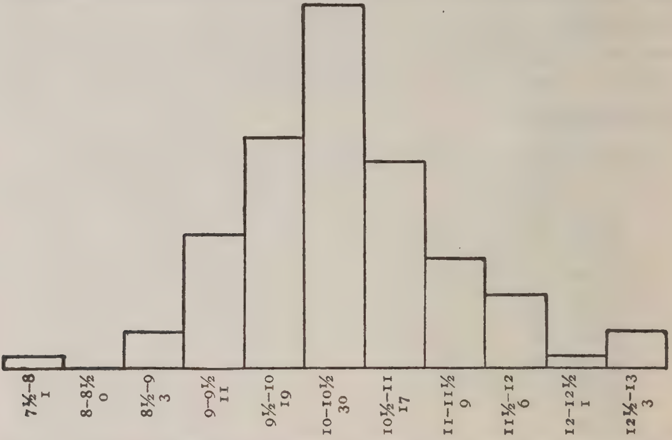

Fig. 1.—Distribution of the mental ages of one hundred ten-year-old school children.

to be distributed symmetrically, in accordance with normal distribution, around the median mental age. As a matter of fact, however, the distribution curves do not prove the accuracy of the tests. Rather they have value only insofar as we may assume that accuracy has been attained.

We know that the tests are accurate in regard to the average result with large groups. This is proved, as I have indicated, by the equality between the median mental age and the chronological age of the group. To prove their accuracy in individual cases is much more difficult, for there is no way to make certain that a measurement of any particular child's intelligence is correct without knowing beforehand how intelligent the child is. And how are we to determine the intelligence of a child except by the use of our measuring scale? There is no certain method. We must go ahead and make our measurements, then watch to see whether or not the future success of the child harmonizes with them. Of great aid is the rating given the child by his teachers and the progress he makes in school.

The most accurate rating of the intelligence of children that can be secured from school work is that obtained by classifying children of the same age according to their grade. In any school system, children of one certain age are scattered over four or five grades; and it is reasonable to suppose that those who are in the lower grades are less intelligent than those of the same age in the upper grades. Certainly there are many objections to assuming a perfect correspondence between school grade and intelligence; but it is reasonable to expect a considerable correlation. Investigation shows that this correlation exists. The revised Binet tests show for children of each age a regular increase in mental age with the grade attained. For example, eleven-year-old children who are still in the second or third grade instead of the fourth or fifth, will usually be found to be several years below eleven in mental age, whereas eleven-year-old children who have reached the sixth or seventh grade will be found to average a year or so above eleven in mental age. Similar results have been obtained for all the school ages.[15]

Exceptions to the correspondence between mental age and school standing are very common indeed. A careful study of these exceptions, however, usually leads to the strongest possible proof of the accuracy of the intelligence tests. There are two cases very frequently met with: One, that of the child who has been promoted because of his age regardless of scholastic attainments, the other, more serious, that of the child who has lost interest in his work and has been retarded because his teacher failed to understand his personality or to appreciate his mental gifts. The promotion of children simply on account of their age is a phenomenon with which all teachers are familiar; the holding back of really brilliant children is not so commonly recognized. By the study of these latter cases, however, more readily than in any other way, will one acquire respect for the Binet intelligence tests. As a striking illustration, consider the case of Louis R.

Louis was nine years and ten months old. When tested, he was found to have a mental age of twelve years and nine months, nearly three years ahead of his chronological age. So high a mental age is very unusual for a nine-year-old child. It indicated that he had sufficient mental ability to do work of the fifth or sixth grade. Actually, he was in the "B" class of the fourth grade. Now which was the true indicator of his intelligence, his school grade or the mental age given by the intelligence tests? His record will show.

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[15] See Kuhlmann, "Some Results of Examining a Thousand Public School Children, with a Revision of the Binet-Simon Tests of Intelligence by Untrained Examiners." *Journal of Psycho-Asthenics,* vol. xviii, 1914, pp. 242–245.

The following extract was taken from the teacher's report to the superintendent in January:

> Louis R. was not promoted to the "A" class of the fourth grade, because his work in the "B" class does not show continuous improvement, but is erratic. If he would apply himself he could do the work fairly well, but he will do one or two problems in arithmetic and let the rest go. He spends most of his time trying to make aeroplanes, etc., out of paper, or by whittling them from little blocks of wood which he brings to school. He loses interest in all school work after a few minutes. He learned to do long division with only one explanation—did two problems correctly—then quit trying and failed systematically after that.

The cause of the boy's failure is obvious. His teacher could not establish a point of contact between his active mind and his school work. He is a healthy, energetic German boy whose father is well known all over the state as a wealthy and successful cattleman. His parents want the boy to have every advantage possible.

Louis was tested in January, 1918, and recommended for special promotion. He was also transferred to another building where the fifth grade teacher was an expert with children.

Inquiry was made in May, 1918, regarding the boy's progress, and the fifth-grade teacher said he had again been promoted on trial to "B" sixth grade—except in arithmetic; she was giving him special help in arithmetic out of school hours, so that by fall he could enter the "A" sixth class without condition.

Cases like that of Louis R. are not uncommon. Many such children, considered dullards in school, have developed into men of undoubted genius.[16] Oliver Goldsmith was regarded as a stupid blockhead by his earlier teacher; it was only when he went to a second school that he found a teacher who realized his powerful intellect. Byron was the butt of his class because he did not learn his lessons. Yet at Harrow, he found a teacher who recognized his talents. "I soon found," said this teacher, "that a wild mountain colt had been committed to my care. But there was mind in his eye." Clearly there is a great field of usefulness for the Binet tests in the discovery of superior mental abilities which might otherwise pass unnoticed.

Considering all the evidence, one must concede to the Binet tests a high degree of reliability. Their accuracy with groups can be demonstrated with mathematical precision, and their accuracy in the individual case becomes more convincing with use. They certainly offer the best means at hand for the appreciation of child intelligence. With their aid a more accurate rating can be secured in forty minutes than through the teacher's estimates based on a year of observation. At the same time, they are not perfect; and now that we have considered the proofs of their accuracy, it will be well to give attention to some of their limitations.

Criticism of the Binet-Simon Scale.—One of the most serious charges made against the Binet tests is that the ability to pass them depends too much upon the accidents of schooling and of environment, that it is not wholly decided by ingrained capacity which alone is properly called intelligence, but upon the favorableness of the child's early training. It is said that a child who has not been to school at all could not pass some of the tests which a child who had been in school could manage without difficulty. That the tests are not altogether free from this error may be admitted, but the charge is not so serious as it might seem, for the Binet tests are not concerned with those things which a child has to be taught, but only with those things which a child naturally learns as he grows older.

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[16] Swift, "Mind in the Making," 1908, pp. 95–115.

After all, whether or not a child acquires knowledge depends largely upon his innate intelligence. Any ordinary environment offers abundant opportunities for the acquisition of all the knowledge required by the revised Binet tests. Whether this little knowledge is acquired or not may then be simply a question of the child's capacity to take advantage of his opportunities; and it is precisely this capacity to take advantage of opportunities which is meant by intelligence and which it is the aim of the tests to measure.

It may in general be said that a child's mental age is determined by growth of capacities rather than by what he learns. I have found that feeble-minded children of nine years mental age improve with practice in simple mental operations just as rapidly as do normal children of the same mental age.[17] Yet in spite of this ability to learn, the feeble-minded children did not increase in mental age. Practically they remained at the mental age of nine years. They averaged fourteen years chronologically and probably had reached their maximum mental age. Evidently, then, the ability to change from a low mental age to a higher is not a matter of learning power. It is a capacity for mental growth. What a child can learn and how fast he can learn, depends upon his mental age; but learning does not greatly affect the rate of growth in mental age. This is true of adults. They continue to learn throughout their lives; but they do not continue to increase in mental age after they have reached the adult stage.

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[17] Woodrow, "Practice and Transference in Normal and Feeble-Minded Children." *Journal of Educational Psychology,* vol. viii, 1917, pp. 85–96 and 151–165.

Another consideration, sometimes urged as a shortcoming of the Binet tests is that they fail to detect all mental abnormalities. They do not serve for the diagnosis of such disorders as epilepsy or hysteria, nor for the measurement of criminal tendencies. They do not always bring to light such defects of character as laziness, ungovernable temper, uncontrollable sex impulses, and openness to suggestion. These are not valid objections, however. The aim of the Binet tests is solely to measure intelligence. The analysis of character is a different matter. Nevertheless, the Binet tests have been of great value in making clearer the relationship between intelligence and character. By their use it has been established that a considerable percentage of persons convicted of crime and immorality are of very low mentality. They are widely used in juvenile courts, where they are of great value in enabling the judge to form an idea of the probable future of the child. They have even saved the lives of youthful murderers by proving that the murderers were imbeciles who could not possibly understand the nature and seriousness of their act.[18]

One other limitation of the Binet tests which should be kept in mind is that they do not entail a rigid mechanical procedure which does away with the personality of the one who uses it. It is of course true that not the slightest detail of the tests may be changed; the directions for giving them must be strictly followed. Even so, the influence of the tester's personality cannot be entirely eliminated. And when the measurement is completed, the result should never be regarded as an end accomplished, but merely as one means toward a better estimate of the child's mentality. The Binet tests must always be supplemented by further observations, and interpreted in the light of all the knowledge that can be obtained concerning the child's health and physical condition, his school record, his parents and his home life. The Binet tests do not suspend the need for expert insight into child nature nor the need for common sense on the part of the person who is to realize their full value.

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[18] Goddard, "A Brief Report on Two Cases of Criminal Imbecility." *Journal of Psycho-Asthenics*, vol. xix, 1914, pp. 32–35.

All in all, the Binet measuring scale is a wonderful achievement. Psychology has made no other single contribution that is of such great practical value to the science and the art of education. The Binet scale has not only afforded the means of proving the absolute necessity for greater adaptation of education to the possibilities of the individual pupil, but it stands as the most serviceable instrument for the determination of those possibilities. It is the confident prediction of many educators that intelligence tests will soon become part of the necessary routine of the schoolroom; and in all probability the day is not far off. Already they are in extensive use throughout the schools of many nations.

Group Tests.—Anticipating the extension of mental testing to all school children, psychologists have for some time been at work on the perfection of group tests for children. Group tests cannot take the place of the individual examination. The idea is that they can be made sufficiently accurate for rapid surveys to determine those who should be tested individually. One such system of group tests [19] is largely an ingenious adaptation of various revisions of the Binet tests to group work. It has been used in a survey of the schools of an entire county in Minnesota, to locate all cases of doubtful mentality. Another system is constructed along lines quite different from the Binet scale.[20] Instead of giving different tests at each age, it gives the same tests at all ages. These tests, however, are not tests which a child either passes or fails, but tests in which he obtains a certain score, which may be either high or low, as in a spelling test or an arithmetic test. The intelligence of the child is evaluated by comparing the scores he makes in the various tests with norms that have been established by giving the tests to a large number of children of each age. During the World War, it was decided to give group intelligence tests to all the soldiers in the United States Army. These tests were of immense value, because, as the records prove, a man's success in the army corresponded to a considerable degree with the score he was able to make in the tests—this, notwithstanding the obvious need in military service for certain traits of physique and character as well as of intelligence. An outgrowth of the army tests are the National Intelligence Tests, a set of tests designed for use in school grades above the second. There exist now more than two score of group tests, so rapid has been their development in the few years since the appearance of the earliest sets—those devised by Otis and by the Pressey's.[21]

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[19] Frances Lowell, "A Group Intelligence Scale for Primary Grades," *Journal of Applied Psychology,* vol. iii, 1919, pp. 215–247.

[20] Arthur and Woodrow, "An Absolute Intelligence Scale," *Journal of Applied Psychology,* vol. iii, 1919, pp. 118–137.

[21] An annoted list of thirty group intelligence tests appears in the *Journal of Educational Pyschology,* vol. xii, 1921, pp. 103–108.

CHAPTER III

BRIGHTNESS AND DULLNESS

Distinction Between Mental Age and Brightness.—The word *intelligence* has two quite distinct meanings, which need to be carefully kept in mind. In one sense, intelligence is something which increases in amount with age. It is that which is measured by mental age. In this sense of the term, a child of ten years of age has much more intelligence than a child of three years of age, even if the ten-year-old child is dull and the three-year-old is bright. In the other sense of the term, intelligence is something that remains more or less constant throughout life. This is the sense in which one employs the term when he speaks of a child as highly intelligent without specifying his age. What one really means, in this case, is that the child has more intelligence than other children of his own age. In the first sense of the term, intelligence is an absolute amount, like height described in inches; in the second, a relation, like height described as tallness or shortness.

Throughout the present discussion the term intelligence, if unqualified, is used only in the first sense, in the sense of mental age. This makes it necessary to decide upon a different name for intelligence in the second sense. The proposal has been made to use the term brightness, meaning by brightness any degree thereof from extreme idiocy to genius of the highest order. I have adopted this proposal, and shall use the word brightness in this broad sense. It is less awkward than the term relative intelligence. Children who are ordinarily called bright, that is, children who are the opposite of dull, we shall term superior. Thus, according to this terminology, both dullness and superiority are degrees of brightness, dullness being a low degree of brightness and superiority a high degree of brightness.

The mental age of a child does not tell us how bright he is. Two children may have the same mental ages and yet differ enormously in brightness. Obviously, the meaning of a given mental age depends upon the chronological age that goes with it. If a child's mental age is much less than his chronological age, he is dull; if it is greater, he is superior. But if we ask *how much* less or how much greater, we immediately raise the whole problem of the classification of children. The problem is an important one. Sensible planning of a child's education must presuppose an estimate of the degree of his brightness. In borderline cases, the whole educational procedure often depends upon whether the child is feeble-minded or not; and in the case of any child, it is impossible intelligently to plan his future and to decide upon the best educational methods unless the child has first been properly classified as regards his degree of brightness.

The Lowest Degrees of Brightness.—*Definitions in Terms of Social Status.*—Until recently, the classification of children was in a chaotic condition. Particularly in the case of normal and supernormal children little effort was made to distinguish the different grades. These children were left to look out for themselves. It was only in the lower grades, where the educational and social problems were acute, that the need for classification appeared imperative. Here effort centered upon the distinction between the normal and the mentally defective, and between the various grades of the mentally defective.

Until the introduction of the Binet tests, the most widely accepted definitions of mental defectiveness and its degrees were those suggested by the Royal College of Physicians in London, and adopted by the Royal Commission on the Care and Control of the Feeble-minded.[1] These definitions distinguish three degrees of mental defect, namely, idiocy, imbecility, and feeble-mindedness. The feeble-minded person, the highest of these three grades, is defined as " one who is capable of earning a living under favorable circumstances, but is incapable, from mental defect existing from birth, or from an early age, (*a*) of competing on equal terms with his normal fellows; or (*b*) of managing himself and his affairs with ordinary prudence." The imbecile, a grade below the feeble-minded, is defined as incapable of earning his own living, but able to guard himself against common physical dangers; the idiot, as unable to guard himself against common physical dangers. These definitions are not only indefinite, but they could not be applied very well to children. For feeble-minded children, another definition was framed: They are " those children who, not being imbecile, and not being merely dull and backward, are, by reason of mental defect, incapable of receiving proper benefit from the instruction in the ordinary public elementary schools, but are not incapable by reason of such defect of receiving benefit in special classes or schools."

These definitions of the British Royal Commission emphasize the social aspect of mental defect. There is little doubt that social inefficiency is the most important practical manifestation of the condition. In an adult, social inefficiency means inability to conduct one's self without the guardianship of another, and inability to perform work sufficiently remunerative to supply one's needs. An adult of the highest class of the mentally defective can support himself, but only under favorable circumstances. In a child, social inefficiency means primarily inability to profit from the ordinary classes of the public schools. The social criterion of mental defectiveness calls attention to an important aspect, but beyond that it is vague. Moreover, social incompetence may be due to other causes than mental weakness.[2]

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[1] " Royal Commission on the Care and Control of the Feeble-Minded." *Reports and Minutes of Evidence,* 8 vols., 1908.

Definitions in Terms of Mental Age.—Accurate definition was clearly impossible without the aid of mental measurement. Binet and Simon gave the world a means for defining in their scale for measuring mental age. The possibility of measuring mental age having been established, tentative definitions of mental defectiveness and its degrees, in terms of mental age, were promptly formulated by the committee on classification of the American Association for the Study of the Feeble-minded.[3]

These formulations applied the term feeble-mindedness to all degrees of mental defect, and then divided the feeble-minded into three classes, as follows:

(*a*) Idiots: Those so deeply defective that their mental development does not exceed that of a normal child of about two years. (*b*) Imbeciles: Those whose mental development is higher than that of an idiot, but does not exceed that of a normal child of about seven years. (*c*) Morons: Those whose mental development is above that of an imbecile but does not exceed that of a child of about twelve years. These ages will likely need revision.

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[2] See Doll, "Clinical Studies in Feeble-Mindedness," 1917, pp. 23–26.

[3] "Report of Committee on Classification of Feeble-Minded." *Journal of Psycho-Asthenics,* vol. xv, 1910, p. 61.

The term *moron,* a Greek word, is a new term,[4] adopted upon the recommendation of Dr. Goddard, and now in common use throughout the country. It signifies a person conspicuously lacking in judgment and good sense. The desirability of this new term arose from the fact that the term feeble-minded, which is used in England to designate only the highest class of mental defectives, had long been used in America to include all three classes, so that it seemed best to continue this use, rather than to adopt the English term *amentia.* A feeble-minded person in American usage is an *ament* in the English; and a moron, in the American usage, is a feeble-minded person, in the English. Both countries agree in the use of the terms imbecile and idiot. I shall hereafter follow the American usage.

Years of Retardation as a Basis for Definition of Degrees of Brightness.—The above definitions of grades of feeble-mindedness in terms of mental age are only tentative and not entirely satisfactory. They are workable only in regard to adults, for until an individual is fully matured, we do not know what mental age he may finally attain. To avoid this difficulty, feeble-mindedness has sometimes been defined in terms of years of retardation, found by subtracting the mental age from the chronological age. It is necessary to remember, however, that years of retardation at an early age are much more serious than at a later one. Thus, a child of four who is three years retarded, and therefore one year old mentally, is far more defective than a child of ten who is retarded a like number of years, and consequently of mental age seven. The former child, by the age of ten, will have a mental age far below seven, very likely one of not over three.

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[4] It conforms with the term *morosis*, used over a century ago by Linnaeus to designate the condition of severe feeble-mindedness. Nowadays, to express the condition of a moron, the term moronity is used in place of morosis.

In general, the degree of retardation increases as a child becomes older. His normal companions leave him farther and farther behind. This is illustrated by the following diagram (Fig. 2), representing growth in mental age. This diagram is largely schematical, though based on experimental data concerning the decrease in the size of the step from one age to the next as the higher ages are reached. That this decrease actually exists can be easily observed. For example, the difference in mental attainments between a three-year-old and a four-year-old child are plainly greater than that between a fourteen-year-old and a fifteen-year-old. In both cases, it is true, the difference is one year of mental age, but a year of mental age at the younger ages means a bigger change than it does at the higher ages.

The verdict of common observation in this matter is corroborated by the results of scientific tests. This may be seen by a comparison of the percentages of children passing certain tests. For example, a mental test which fifty per cent. of three-year-olds can pass will be passed by almost all four-year-olds, at any rate, by ninety per cent. of them. On the other hand, it is practically impossible to find a test which only fifty per cent. of fourteen-year-olds can pass which can yet be passed by ninety (or even seventy) per cent. of fifteen-year-olds. Considerable actual data exist on this matter. Thus Bobertag, who gave a number of the Binet tests to both seven- and eight-year-old children, found that while the average percentage of seven-year-olds passing the tests was only 45, the average percentage of eight-year-olds was over 76, an increase of over 31 per cent. He then tried the same experiment with another selection of Binet tests upon children aged eleven and twelve. In this case, he found that the percentage of twelve-year-olds who passed the tests was only 16 greater than the percentage of eleven-year-olds passing. Since the increase in the percentage of children passing the tests is twice as great between the ages of seven and eight as between the ages of eleven and twelve, we are entitled to conclude that the differences in mental ability between the former ages is greater than that between the latter. In general, the difference between two groups of children of different ages, in the percentages passing the same tests, serves as a measure of the difference in mental ability between the two groups. On this basis, it is possible to arrive at an estimate of the size of the step in mental ability between any two ages. It is from such estimates that the accompanying diagram is derived.

The diagram shows that the difference between the dull child and the bright one becomes much greater as they grow older. Not only does the difference when measured in years of mental age become greater, but even allowing for the fact, as I have done in the diagram, that a year's mental growth at the higher ages amounts to less than it does at the lower ones, the difference in intelligence still increases with age. This is shown in the diagram by the fact that the three curves become farther apart as they ascend to the right. A small distance between the curves at the age of one or two becomes a large distance at the age of fifteen or sixteen. This means that slight mental retardation at the age of two, when measured in terms of years, is as serious as great retardation at the age of fifteen. One year of retardation at two years of age is many times as serious as one year at fifteen years of age. Because a year of mental retardation means different things at different ages, it is not very convenient to describe the brightness of children in terms of such a unit. This consideration led to a very helpful proposal by several authorities for the adoption of the "intelligence quotient."

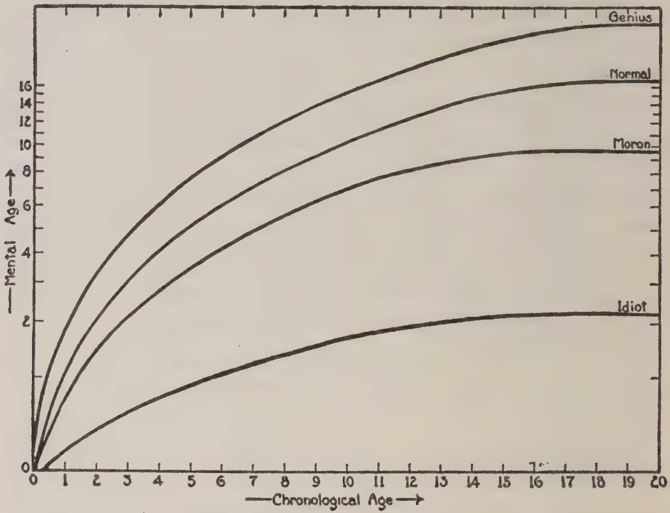

FIG. 2.—Growth in mental age.

Intelligence Quotients.—The intelligence quotient represents a comparison between the intelligence of a particular child and that of normal children of his own age. It is the quotient obtained by dividing a child's mental age by his chronological age. It thus expresses a child's intelligence as a fraction of the intelligence that is normal for his age. If he has more intelligence than normal, his intelligence quotient is more than one; if he has less intelligence than normal, it is less than one. For example, if the mental age of a child ten years old is twelve, his intelligence quotient is the quotient obtained by dividing twelve by ten, or 1.2; if his mental age is ten, he is normal, and his intelligence quotient is 1.0; but if his mental age is only seven, his intelligence quotient is 0.7. A mental age expresses an amount of intelligence, whereas an intelligence quotient expresses a degree of brightness.

The worth of an intelligence quotient depends largely upon the extent to which it remains constant throughout the years of childhood. If the intelligence quotient of a child remains constant, there is no other item of information that is of greater interest to his parents or of greater value in directing his education, for at any age his mental age will be the same fraction of his chronological age, and we can predict very early just what intelligence he will have when he is grown. Thus if, at the age of four, a child's mental age is three and his intelligence quotient is seventy-five per cent., we can predict that at the age of twelve his intelligence quotient will still be seventy-five per cent. and that consequently his mental age will be seventy-five per cent. of twelve, or nine.

The data at hand indicate that intelligence quotients tend as a rule to remain sufficiently constant for practical purposes.[5] We still need many more measurements of the same children at several different ages; for only by such measurements can we determine how often and how much the quotients change as the children grow older. Such tests as have been made, however, indicate that children with a high quotient retain that high quotient as they grow older; that those who are average remain average; and that those with a low quotient retain their low quotient. In the feeble-minded—those with very low quotients—there is some tendency for the intelligence quotient to decrease with age. The facts, then, offer little basis for the common hope that a child who is lacking in brightness at an early age will "catch up" later, perhaps by a spurt at the time of puberty. On the other hand, there is every reason to expect that a child of a high degree of brightness will maintain his mental superiority all along the way into adult life.

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[5] Kuhlmann, "What Constitutes Feeble-Mindedness?" *Journal of Psycho-Asthenics*, vol. xix, 1915, p. 232; and Terman, "The Stanford Revision and Extension of the Binet-Simon Scale for Measuring Intelligence," 1917, pp. 51–61.

There must of course be some age at which the intelligence quotient begins to decrease. This is the age at which the growth of intelligence ceases, beyond which there is no increase in mental age. Now since chronological age, which is the divisor used in obtaining the intelligent quotient, must continue to increase as long as the individual lives, it is evident that when mental age, the numerator, stops increasing, the intelligence quotient must begin to decrease. For example, suppose the mental age of the average person does not increase after the age of fourteen; then an individual who was just normal at fourteen and hence had an intelligent quotient of 1.0 at that age, would at the age of twenty-eight have a quotient of only one-half, since he would at the age of twenty-eight still have the same mental age of fourteen, and consequently have for his intelligence quotient the quotient obtained by dividing fourteen by twenty-eight.

It may seem curious to speak of the cessation of growth in intelligence before the prime of life, usually not reached before the age of thirty-five or forty. This is because people commonly overlook the distinction between capacity and the acquisitions of experience. Intelligence refers only to the former. It means mental power, and not knowledge acquired by the use of that power. It is general ability, not expertness along some one line. The age at which intelligence reaches its maximum is the age at which there is no further growth of such abilities as those of memorizing, of concentrating attention, learning, or reasoning about new topics. It is certain that, for nearly all individuals, this age is below twenty. One may go on acquiring knowledge and wisdom all his life, but he works always with the same mental tools.

The cessation of growth in intelligence is so gradual that it has not yet been possible to determine with precision at what age it takes place. Investigators have usually found the maximum mental age for the average individual to be either fifteen or sixteen, but the tests of intelligence made in the United States army during the recent war, indicate that the average citizen does not reach a mental age of over fourteen. Evidence is offered by the fact that *average persons* of these ages can pass the same mental tests as can *average* adults of any age. For example, the majority of a group, made up of business men of little education, and of high school students over sixteen years of age, would not be likely to pass any harder mental tests than would average persons of ages fourteen, fifteen or sixteen.

Now if the normal adult does not reach a mental age higher than that of fourteen, how are we to state in terms of mental age the brightness of a superior adult? Since any mental age is defined as that degree of intelligence possessed by the average normal individual of that age, and the average normal individual does not reach a mental age above fourteen, it seems impossible to have mental ages above fourteen. Strictly speaking, it is. The difficulty may be arbitrarily overcome, however, by taking as tests for fifteen-year-old intelligence a set of tests which can be passed by only a certain percentage of those who pass the fourteen-year-old tests. By similar procedure, tests may be established for still higher, theoretical, mental ages. In calculating the mental quotient of an adult, then, one would proceed as usual, except that he would divide the obtained mental age by fourteen, no matter how much above fourteen the chronological age might be.

On the whole the intelligence quotient serves as a fairly satisfactory index of brightness in children. The difficulties which it offers with adults do not exist with children up to the age of fourteen or fifteen. One should of course be extremely cautious in making predictions. One cannot say that because a child has a mental age of four at six that he will have a mental age of eight at twelve. All that can be said is that at twelve he is more likely to have a mental age of eight than any other mental age. The intelligence quotient can not be expected to remain constant except for the average. Even so, it offers the best basis at hand for the classification of children in regard to brightness. It can be used to describe any degree of brightness from idiocy to genius.

Application of Intelligence Quotients to the Definition of All Degrees of Brightness.—Before applying the intelligence quotient to the definition of various classes of children, it is necessary first to consider what variation in this quotient exists among children of a given age. Measurements by means of the Binet-Simon scale have clearly established the fact, strongly suspected before.[6] that there is no gap or sharp line of separation between any two grades of brightness. The distribution of mental quotients is the same as that of mental ages.[7] At each chronological age, we find children of each degree of brightness from idiocy up to genius. They occur in numbers which gradually increase as we pass from idiocy to the medium degrees of intelligence, and then gradually fall off again as we pass on up to the highest grade.

Because decrease in the number of any class, as we proceed in either direction from the average, is gradual, the boundary lines between one class and another are somewhat arbitrarily drawn. Wherever we draw them, there will always be a large number of " borderline cases." For example, what mental quotient we select as the boundary between the feeble-minded child and the " dull but normal " one, depends merely upon what percentage of the population we wish to term feeble-minded. If we agree to define feeble-mindedness as the dullest one per cent.,[9] then we will take as its upper boundary an intelligence quotient of seventy per cent., since one per cent. of children have an intelligence quotient of seventy per cent.,[8] or below. Admitting the arbitrariness of all definitions, we may tentatively accept the following system of classification.

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[6] Norsworthy, " The Psychology of Mentally Deficient Children," 1906, p. 80.

[7] See previous chapter, p. 32.

[8] See Pintner and Paterson, " A Psychological Basis for the Diagnosis of Feeble-Mindedness," *Journal of Criminal Law and Criminology,* vol. vii, 1916, and J. B. Miner, " A Percentage Definition of Intellectual Deficiency," Proceedings of the Twenty-fourth Annual Meeting of the American Psychological Association. *Psychological Bulletin,* vol. xiii, 1916, p. 89.

CLASSIFICATION OF BRIGHTNESS DEGREES

Class	*I. Q.**	Percentage of all children included
Gifted, near-genius or genius	Above 1.40	0.25
Very superior	1.20–1.40	6.75
Superior	1.10–1.20	13.00
Normal, or average	.90–1.10	60.00
Dull, rarely feeble-minded	.80– .90	13.00
Borderline, sometimes dull, often feeble-minded	.70– .80	6.00
Feeble-minded	Below .70	1.00
Moron	.50– .70	.75
Imbecile	.20 or .25– .50	.19
Idiot	Below .20 or .25	.06

* I. Q. is a common abbreviation for intelligence quotient.

The above table shows that the majority of children, namely, sixty per cent., belong in the class called normal. Above and below the normal are the superior and the dull, each composing thirteen per cent. of the total number. In place of the term superior, we could substitute that of bright. In ordinary usage, brightness means superiority, but, as I have explained, the term brightness is needed in order to include all degrees of relative intelligence. Consequently, for brightness in the narrow sense, the word superiority is preferable, because it prevents confusion.

There are several classes of children not mentioned in the table. These are usually not defined with any accuracy. One of these is the backward class. The term backward would be a useful one to designate children who appear to be dull, but whose dullness, there is reason to believe, is only apparent or temporary. Then the term *dull* would be used when the inferiority was innate and presumably permanent and the term *backward* when there was reason to believe that it was only temporary, and would be outgrown. The class called mentally retarded, and that called subnormal, includes all the classes below the grade of normal. Occasionally one hears the rather ambiguous phrase, dull but normal. This expression is intended to emphasize the fact that the child is not feeble-minded. It means dull but not feeble-minded.

In this classification of brightness degrees, it will be observed that the significance of a mental quotient is sometimes doubtful. This is indicated in the table in the case of quotients falling between seventy and eighty, and between eighty and ninety. The reason for this is that the exact diagnostic significance of a mental quotient is always doubtful. This is chiefly because of three considerations.

First, all systems of tests yet devised are somewhat ambiguous in respect to what they measure. They aim to measure *intelligence;* but, admitting that they succeed fairly well in this aim, it must yet be conceded that the measurements are not entirely free from error. To measure intelligence, they would have to measure capacity altogether apart from learning, practice, or opportunity, and apart from any effects due merely to the chronological age of the child, that is, to mere oldness of mind.

A second consideration is that, entirely apart from the question of *what* the tests measure, there is always present in a particular case the possibility of a large error in the *accuracy* of the measurement. It is impossible to be positive in any individual case that the real mental age does not differ considerably from the one actually obtained. This remains true no matter how carefully the tests are given, for there remains the possibility that the particular tests used are not well adapted to testing the intelligence of the particular case at hand.

The third consideration affecting the interpretation of intelligence quotients is that standards are different in different groups of people. They vary with race, social class, and sex. I shall therefore discuss the effect of each of these. The facts are very interesting and of immense importance in the understanding of social questions.

Race, Class and Sex Differences in Intelligence.—The matter of race differences obviously raises important questions. One of these is the age at which the different races reach their maximum development of intelligence. There is some evidence that races vary considerably in this respect. For example, it appears that the aboriginal children of South Australia complete their growth in intelligence several years earlier than do white children.[9]

Another question is that of types or kinds of intelligence. It may be that there are no racial differences in type, so far as general intelligence itself is concerned. But we can *measure* intelligence only through the performances in which it is manifested; and it is certain that different races manifest their intelligence in different ways. If different races show different types of intelligence, or rather, if they show their intelligence in different ways, it becomes necessary to have different sets of tests for different races.

In America, where the race problem is acute, the difference between white and colored children is an interesting subject. In an investigation conducted in Columbia, South Carolina,[10] it was found that, as we should expect, the majority of white children tested "at age." The largest number of colored children, on the other hand, tested one year below age. It follows, then, that if we take tests that have been standardized for white children and apply them to colored children the latter will not do as well as the white children. If we use such tests in the diagnosis of brightness, we obtain a very much larger percentage of feeble-mindedness for the colored population than for the white. Some people, no doubt, would find no objection to this result; and, in itself, it is extremely valuable information. Yet, whatever we may think of the relative intelligence of the negro and the white man, in diagnosing the case of an individual negro, it hardly seems proper to call him dull if, as a matter of fact, he is a normal *negro*.

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[9] Porteus, "Mental Tests with Delinquents and Australian Aboriginal Children." *Psychological Review*, vol. xxiv, 1917, p. 32.

[10] Strong, "White and Colored Children Measured by the Binet-Simon Measuring Scale of Intelligence." *Pedagogical Seminary*, vol. xx, 1913, pp. 485–513.

Fully as important as race differences are those due to social status. It has been well established that, on the average, children of the "lower" classes—the laboring classes—the wage earners and the men of small business—have a lower mental age than children of the "higher" classes—the professional classes, and the successful business men, always providing that the chronological ages are the same.

One interesting study of this highly important matter was conducted by the school teachers of Breslau, Germany. This city maintained two elementary public schools, one called the Vorschule and the other the Volkschule. The Vorschule was attended by children of the higher social classes, whereas the Volkschule was made up of children of the laboring and lower business classes. Children could enter the gymnasium, with its nine-year curriculum preparing for the University, after three years of preparation in the Vorschule, but only after four years in the Volkschule. Now, upon the demand for a common school for all classes to replace the Vorschule and the

Volkschule, an investigation was made of the intelligence of children in the two schools by means of a revision of the Binet scale. It was found that the children of the select Vorschule did much better than those of the Volkschule, nine-year-old boys in the former attaining the average of ten-year-old boys in the latter.[11]

In the United States, the situation is similar to that in Breslau. For example, in Cambridge, Massachusetts, a comparison was made of children in the kindergarten and first grade of two schools, one of which was located in a "good" neighborhood and the other in one of the poorer sections of the city. Six-year-old children from the good neighborhood were found to do better than seven-year-old children from the poorer one.[12]

Another investigation consisting of a study of the brightness of children according to the occupation of their fathers was made in Columbus, Ohio.[13] The results obtained are summarized in the accompanying table.

On the whole, the data at hand indicate that the difference in brightness between children of the lower and upper classes is marked. The difference increases with the age of the children, until at the age of fourteen the children of the superior classes are about one year of mental age in advance, and those of the inferior classes about one year of mental age behind, the average.[14]

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[11] Hoffman, "Vergleichende Intelligenzprüfungen an Vorschülern und Volkschülern." *Zeitschrift für Angewandte Psychologie,* vol. viii, 1914, pp. 102–120.

[12] Yerkes and Anderson, "The Importance of Social Status as Indicated by the Results of the Point Scale Method of Measuring Mental Capacity." *Journal of Educational Psychology,* vol. vi, 1915, pp. 137–150.

[13] Bridges and Coler, "The Relation of Intelligence to Social Status." *Psychological Review,* vol. xxiv, 1917, pp. 1–31.

[14] See Terman "The Measurement of Intelligence," p. 72.

Mental Age of Children According to Social Status of Parents

Social status	No. children tested	Chronological age	Mental age	Intelligence quotient
Professional: Professors, doctors, lawyers, editors.......	32	7 yrs. 3 mos.	9 yrs. 8 mos.	1.33
Salesmen: Including insurance and real estate.............	39	7 yrs. 6 mos.	9 yrs. 2 mos.	1.22
Proprietors: Also managers, officers and contractors....	34	7 yrs. 10 mos.	9 yrs. 1 mo.	1.16
Clerical workers: Clerks, bookkeepers, accountants, cashiers...........	17	7 yrs. 10 mos.	9 yrs. 1 mo.	1.16
Skilled laborers: Mechanics, metal workers, building trades.............	63	8 yrs. 0 mos.	7 yrs. 10 mos.	.98
Unskilled laborers....	60	8 yrs. 0 mos.	7 yrs. 1 mos.	.89
Teamsters...........	18	7 yrs. 10 mos.	7 yrs. 0 mos.	.89

Similar conclusions have been reached regarding the school success of children. One study, made in Pittsburgh, finds that fifty per cent. of the children who are well advanced in their school work come from homes which have telephones, and that only nineteen per cent. of those who are below grade come from such homes.[15] If we can consider a home's possession of a telephone of any value as an index of its economical standing, clearly those children coming from the homes financially comfortable do better in school than those from poor homes. This finding agrees perfectly with the fact that children from better homes have a higher level of intelligence.

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[15] Kornhauser, "The Economic Standing of Parents and the Intelligence of Their Children." *Journal of Educational Psychology,* vol. ix, 1918, pp. 159–164.

Besides a child's race and social class, we have to take into consideration his sex. There is a slight difference in type of intelligence between boys and girls. The boys seem to excel in some tests and the girls in others. The latest studies indicate, moreover, that girls are slightly superior to boys in brightness at all ages from the very earliest up to fourteen. The difference is slight, and amounts, at most ages, to not more than three or four per cent. Up to the age of fourteen, the intelligence quotient of boys standing at the middle of their age group is usually about ninety-seven or ninety-eight per cent., whereas that of girls at the middle of their age group is one or two over one hundred per cent.[16]

In spite of all these complications, the intelligence quotient affords a very useful and easily understood medium for the expression of a child's brightness. It should never be regarded as a mathematically exact diagnosis of mentality. It is but one item, and needs careful interpretation, not only in the light of the child's race, social class, and sex, but also in the light of his physical condition and his entire past history.

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[16] Terman, *op. cit.*, pp. 62–83.

CHAPTER IV

BRAINS

The Relation of Mind to Body.—One of the striking features of modern psychology is the attention given to the relation of intelligence to the bodily organism. An extremely close connection has been found between the activity of the body and that of the mind. This connection is due primarily to the inseparable association of the mind with that part of the body, enclosed within the upper portion of the skull, known as the brain, or cerebrum. The brain is connected with the rest of the body through the nervous system, of which it is a part, and through the circulation of the blood. Intelligence is connected with the body as a whole, but solely through the agency of the brain, so that the most fundamental of the relations of intelligence to the body is its relation to the brain. This relation is discussed in the present chapter. The relation of intelligence to other bodily features and to general physical development will be discussed in the two following chapters.

It is a well-established fact that all mental processes are dependent upon accompanying brain processes. No mental process can occur without a corresponding brain process; no sensation can be felt, no object can be perceived or remembered, and no problem solved through the aid of judgment and reason except through the functioning of the brain. In view of this intimate association of all mental processes with brain processes, we should expect to find a close parallel between intelligence and brain development. Many able scientists have investigated the matter. They have sought to find out just what are the differences between the brains of beings possessing different degrees of intelligence. A great deal more work needs to be done to make our knowledge definite and complete in detail, but the main features of the correlation between brain and intelligence are beginning to be fairly well established.

The Relation of Brain Development to the Evolution of Animal Intelligence.—The relation of the brain to intelligence may be studied in various ways. Most studies have dealt either with brain weight or with brain structure, particularly with its minute structure as revealed by the microscope. Of these two types, the latter has proved much the more enlightening; but both are valuable. Both types of investigation have been made on animals, on children and on adults. Those on children deal with the changes that occur in the brain with growth in intelligence, and it is with these that we are most concerned. The studies on animals and adults, however, also deserve attention.

Examination of the brains of animals, as we follow the path of their evolution from those of lowest intelligence up to man, discloses a direct relationship between the development of the brain of a species and its intelligence. This relationship is shown in the increased weight and the increased complexity of structure of the brains of the higher animals. Concerning brain weight, little needs be said. It is directly related to intelligence, but only in a rough way, and only after corrections are made for a number of factors such as body weight, proportion of fat, and size of the skeleton.

Studies of the microscopic structure of the brain deal mainly with the structure of its outer shell. This shell, called the cerebral cortex, is known to be the part of the brain, or cerebrum, most intimately associated with the operations of the mind. It contains millions of nerve cells, called neurones. Each of these neurones has a large *cell body* from which extend a number of branches or *fibres,* which connect the cells with each other and with other parts of the nervous system. The neurones are arranged in several more or less distinct cortical layers, of which the thickest are the pyramidal layers, so called because they contain cell bodies which are shaped like pyramids, with their apex pointing towards the brain's surface. There is considerable evidence that these pyramidal layers are the ones which are most closely connected with the higher mental processes. Besides the pyramidal cells, there are numerous other types, most of which are shown in Fig. 3.

Ascending the scale of vertebrates, an investigator finds a number of very decided changes in the cerebral cortex. There is an increase in the number of distinguishable layers of neurones and an increase in their thickness. At the same time there is an improvement in the structure of the individual neurones. The cell bodies of the neurones acquire a more finished appearance and show a marked increase in the number and length of the fibres branching from them.[1]

The differences in the cortex between the lower and the higher animals are most decided in the case of the pyramidal layer. The increase in thickness is far greater in this layer than in the others. This layer in the dog is one-half as thick as in the monkey, and in the monkey

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[1] Ramon y Cajal, *Revue Scientifique,* 4th series, vol. iv, 1895, p. 706.

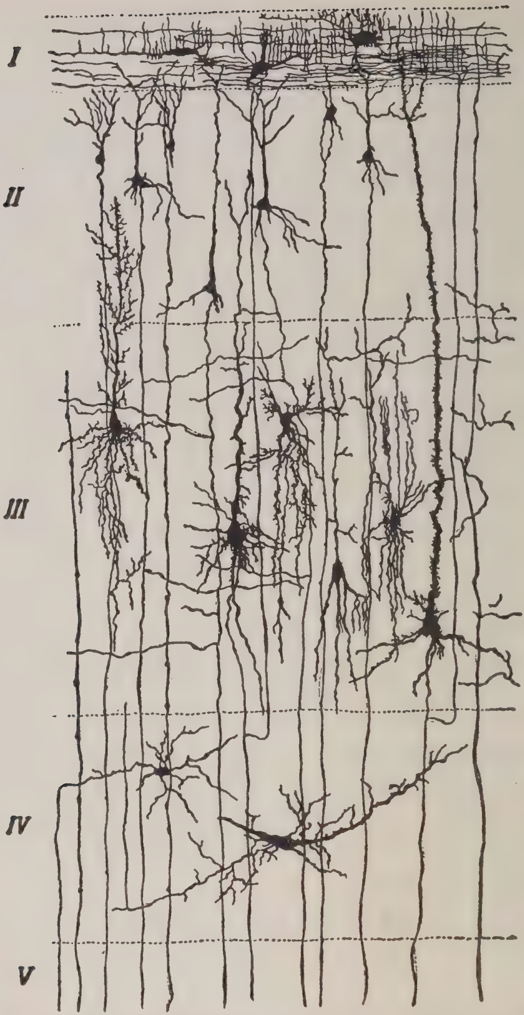

FIG. 3.—Diagrammatic representation of the cortical layers and of the different types of neurones. (After Starr, Strong and Leaming, "Atlas of Nerve Cells," 1896, p. 72.) *I*, superficial layer; *II*, layer of small pyramidal cells; *III*, layer of large pyramidal cells; *IV*, deep layer; *V*, white matter made up of connecting fibres.

it is three-fourths as thick as in the human being. "As a very rough analogy," writes Bolton, "the pyramidal layer of the dog may be compared with that of a still-born infant; and the pyramidal layer of the rhesus (monkey) with that of an imbecile."[2] He claims that very striking differences between man and the animals exist in the pyramidal layer of the anterior portion of the cortex known as the frontal lobes.

The pyramidal layer of the higher animals differs from that of the lower ones, not only in its greater thickness and the greater number of its component cells, but also, far more than does any other layer, by the degree of development of its cells. Development of a nerve cell can be followed by the increase in the size of the cell body, and change in its shape and texture, and also in the number and length of its fibres. Great variation exists in the degree of development of the pyramidal cells in different species. In lower species, the development of these cells is very rudimentary, and even in the adult brain of these species they show little change from their primitive embryonic condition.

That the degree of development of the individual cells is as important as the thickness of a cortical layer, is well illustrated in the guinea-pig. The guinea-pig's intelligence is of a low order; yet the animal possesses a pyramidal layer of considerable thickness. According to the observations of Watson, however, the cells of this layer in the adult are advanced but little beyond their condition in the new-born animal, and development in most cases is so incomplete that it is difficult to credit them with much functional value. This similarity between the pyramidal layer of the adult and the new-born animal, writes Watson, "affords a ready explanation of Miss Allan's observation that there is in the case of the guinea-pig no increase in complexity of psychological processes after the third day of life. It also affords a striking example of the fact that actual depth alone of a cortical layer is not to be altogether relied upon, when endeavoring to compute the functional significance of such a layer."[3]

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[2] "A Contribution to the Localization of Cerebral Function, Based on the Clinico-Pathological Study of Mental Disease." *Brain*, vol. xxxiii, 1910, pp. 106–115.

Thus, from the study of the weight as well as the microscopic structure of the brain, it is evident that the intelligence of an animal species depends upon its brain development. The higher animals have a greater relative brain weight and a better developed cortex. The cortical layers, particularly the pyramidal, are thicker and contain more numerous and better developed cells.

The Development of the Brain in Children.—It has long been established that the stages in the development of a human being run roughly parallel to those in the evolution of animal species. Consequently, we should expect to find that changes occur, in the brain of an individual human being as he develops into an adult, similar to those met with in passing from the lower animals to the higher ones. This expectation, we shall find, is entirely justified.

As regards the changes in the brain which occur with the growth of the human child, we have to consider again both brain weight and microscopic structure. European cases furnish the most reliable and extensive data on increase in brain weight. Dr. Richard Scammon, professor of anatomy in the University of Minnesota, has recently gone over all the existing data with great care. On the basis of all reliable material, excluding cases of disease known directly to affect brain weight, he has constructed a curve of brain growth which is probably the most accurate yet drawn. This curve he has very kindly furnished me, and it appears in figure No. 4. The irregularities in the curve at the higher ages in all probability have no significance. They are due simply to an insufficient number of cases and the fact that the weights for different ages are necessarily those of the brains of different children.

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[3] "The Mammalian Cerebral Cortex, with Special Reference to Its Comparative Histology." *Archives of Neurology*, vol. iii, 1907, pp. 49–117.

The curves of growth in brain weight show some points of very great interest. The most striking thing about the growth of the brain is the very early age at which the greater part of it is completed. Even at birth, the brain is relatively large. It has already attained the fourth part of its final weight, whereas most of the organs of the body at birth have only the tenth to the fourteenth part of their ultimate weight. During the first year of life, the brain grows much more rapidly than at any later time and increases two and one-half times in weight. During the next few years, it continues to grow at a reduced but still rapid rate, until *by the middle of the fifth year, it has reached over ninety per cent. of its final weight.* After the age of five there is only a very small increase, which takes place very slowly, and which is completed not far from puberty. According to Scammon, there is practically no increase in brain weight after fifteen years, and in some cases the entire adult brain weight is acquired by the seventh year. A period of increased brain growth at puberty has been described, but Scammon's examination of practically all the published data on brain weights in children fails to confirm this observation.

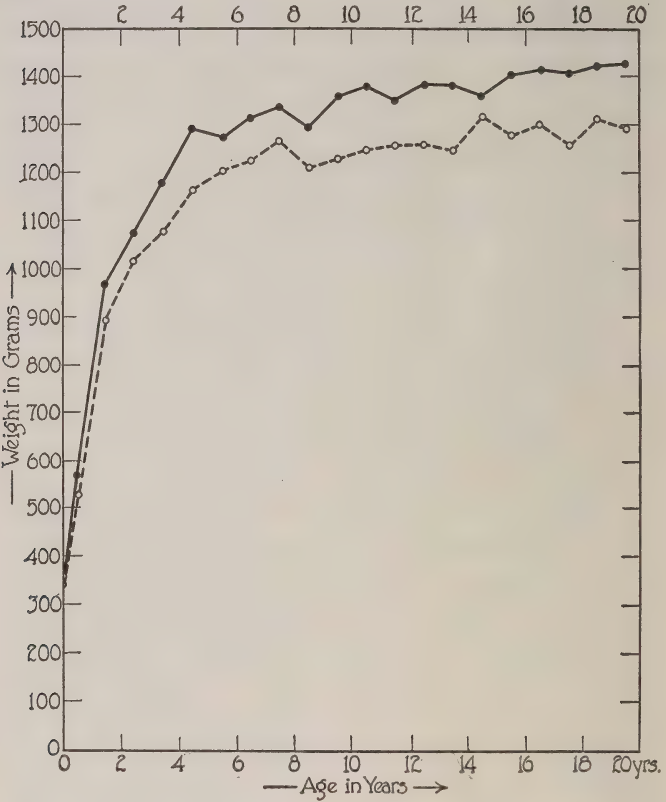

FIG. 4.—The growth of the brain in weight (by kindness of Dr. Scammon). The continuous line is the curve for boys and the dotted line the curve for girls.

A feature of the cerebrum of children which is quite distinctive is the relatively poor development of the frontal lobes. In the new-born child these lobes are comparatively inconspicuous, and consequently have a greater growth to accomplish after birth than have the other parts of the cerebrum.[4]

The fact that the brain completes such a large proportion of its total growth during the first few years of life explains why it is that feeble-mindedness always appears, if at all, at a very early age. Although most feeble-minded children are born so, it is known that a considerable percentage become feeble-minded after birth. But it is a remarkable fact that *no child ever becomes feeble-minded after the age of four or five,* the age at which the brain reaches almost its full weight. Now if the brain of a child who is not born feeble-minded is well nourished during the first four or five years, by that time it will have completed most of its growth. At that age, then, he is comparatively safe, for his brain will already have developed into whatever is in keeping with the potentialities present at birth.

It cannot be too strongly emphasized that the really critical years of a child's life are the years before he enters school. The age of puberty is often spoken of as a critical period, and no doubt it is; but it is incomparably less critical than the first few years of life. There is strong evidence indicating that the level of brightness of a child is determined during these years, whether he be dull or normal. This is indicated by a tendency on the part of intelligence quotients to remain constant after the age of five, or earlier. As long as an intelligence quotient remains constant, the brightness of the child is not changed, for, as the preceding chapter explained, brightness is measured by the intelligence quotient. Now the constancy of intelligence quotients may be far from perfect; but it is great enough to indicate that the brightness of children, in the great majority of cases, is substantially fixed before they ever enter school. Brightness, then, appears to depend solely upon heredity and the proper completion of those brain changes which are reflected in growth in brain weight; and these brain changes, as Dr. Scammon's curve shows, are practically completed by the age of five.

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[4] Pflaunder and Schlossmann, "The Diseases of Children," 2d edition, 1912, vol. iv, p. 124.

Further relations between brain weight and intelligence come to light if we compare their growth curves. Curves of growth in intelligence, showing the increase in intelligence with chronological age, are given in the preceding chapter.[5] The growth curves for intelligence and brain weight agree in showing a much more rapid rise in the first few years than in the later years. They agree also in that both become practically level at about the age of fourteen or fifteen. The intelligence curve, however, differs from the brain curve in that it continues to rise considerably, long after the brain curve has become practically level. There are two possible explanations for this difference. One is that in reality the two curves should correspond, but that they do not because our methods of measuring intelligence are so largely influenced by learning. From this point of view, it might be alleged that what we chart beyond the age of five as a growth in intelligence is merely the effect of practice and experience in increasing the success achieved with an intelligence already fixed, at least in regard to nine-tenths of its final value. The other explanation is that the growth shown by the intelligence curve in the later years of childhood has its brain counterpart in certain microscopic changes in the cortex which are not reflected in brain weight. Here, however, we would have to distinguish carefully between the brain changes corresponding to learning, which continue at a good rate throughout life, and those corresponding to growth of intelligence, which certainly come very nearly to a stop at an age not much beyond fourteen. Between these two explanations it is not now possible to decide with certainty; but in all probability the latter is nearer the truth.

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[5] See page 48.

We may now turn to the microscopic structure of the brain and consider the changes it shows as the child grows older and more intelligent. Studies in human embryology indicate that after the third or fourth month of fœtal life, the number of cells in the cerebral cortex does not increase. Their number, then, is determined well before birth. It follows that the growth changes shown by the microscope consist chiefly either in increase in the size, and change in shape and texture of the cell-bodies, or in the number and structure of the fibres. The cell-bodies at birth are denser and smaller and lack somewhat the profuseness of fibres characteristic of the adult cortex. They are also lacking in a certain pigment which they later acquire. Many of them, particularly the pyramidal cells, have not yet attained their characteristic shape. They appear embryonic and imperfectly formed.

As the child grows older, the cortical nerve fibres acquire an enveloping sheath. The significance of this sheathing process, however, is not well understood. It is supposed to aid in the conduction of the nervous impulse along the fibres. The aquisition of sheaths on the part of the cortical fibres continues through middle life; accordingly it probably has little to do with the determination of the individual's brightness or the fundamental powers of his mind. It appears rather to be correlated with the learning and knowledge that come with experience.

Though very few systematic studies have been made of the changes in the cell structure of the cortex that occur with increase in age, it has been established that the most significant development is that which occurs in the pyramidal layer. The cortical layers lying below the pyramidal complete their development very early. In the six months' fœtus they are as thick as at birth and very nearly as thick as in the adult. The pyramidal layers, on the other hand, are only one-half as thick in the six months' fœtus as at birth and only one-third as thick as in the adult. It is in the thickness of the pyramidal layers that the cortex of man differs most from that of the lower animals; and it is here that we find the greatest difference between the cortex of the new-born infant and the adult.

The fact that the pyramidal layers, which are so poorly developed in the new-born child and in the lower animals, are the ones which are the slowest to reach maturity in the human being, is regarded as evidence that these layers are the ones most closely associated with intelligence. The pyramidal layer, to quote from Watson, " subserves the higher associations, the capacity for which is shown in the educability of the animal. It has therefore to do with all those activities which it is obvious that the animal has acquired or perfected by individual experience, and with all the possible modifications of behavior which may arise in relation to some novel situation, hence with what is usually described as indicating intelligent as apart from instinctive acts." [6]

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[6] " The Mammalian Cerebral Cortex, with Special Reference to Its Histology. I. Order Insectivora." *Archives of Neurology*, vol. iii, 1907, p. 110.

The Relation of the Brain to Differences in Intelligence in Adults.—In confirmation of the results obtained by the study of animals and of the growing child are those obtained from the comparison of persons of different degrees of brightness. The brains of lower and higher animals, as we have seen, differ as regards certain features of their brains in the same manner as do younger and older children. Now if these features really are those which correspond to intelligence, then we should find a marked difference in these same features upon comparing the brains of persons of widely different levels of intelligence.

Brain weights of adults have been determined both for normal individuals and for men of great eminence. The normal male brain has a weight averaging something over 1360 grams. The extreme range, if we exclude idiots, is probably between 1000 and 2000 grams with the majority of cases falling between 1300 and 1500 grams. The weight of the female brain is about 10 per cent. less than that of the male. However, when the weight of the female brain is taken in proportion to physical development, as shown by the weight of the body and the skeleton, it is greater than that of the male. Thus neither sex can claim preëminence from the point of view of cerebral development. The relation of brain weight to physical development in the female is somewhat like that in an undersized male; for in either sex, the smaller the stature, the greater is the relative brain weight.

A comparison of the brain weights of normal men with those of eminently able men is not uninteresting. A number of great men have realized the value to science of post-mortem examination of their brains and have therefore directed that their brains be made available for study. The brain weights of over one hundred of these men have been determined. They range from about 1200 to 2000 grams, thus overlapping the range of brain weights of ordinary men. On the average, however, they weigh about 1470 grams;[7] that is, over one hundred grams more than the average of ordinary individuals. The brain-weights of some of the well-known men is given in the following list:

	Grams
Cuvier, naturalist	1829
Thackeray, novelist	1658
Spurzheim, anatomist and phrenologist	1559
Daniel Webster, statesman	1516
Agassiz, naturalist	1495
Grote, historian	1410
Bertillon, anthropologist	1398
Liebig, chemist	1352
Gambetta, statesman	1294

The brains of exceptionally intelligent men tend to average greater in weight than those of ordinary men, and those of the feeble-minded average less. It has been observed that a brain weight below about 1000 grams is seldom found with an intelligence above the grade of feeble-mindedness. The average brain-weight of adult idiots is probably not over 1200 grams. It should be emphasized, however, that a very large and heavy brain is not incompatible with idiocy. Its size may depend mainly upon an overgrowth of non-nervous tissue at the expense of the nerve cells, or it may be due, as in hydrocephalus, to the accumulation of a large amount of fluid within the brain cavities.

Although a rough correlation between brain-weight and intelligence evidently exists, it is not close enough, in different individuals, to indicate that brain-weight in itself is the important factor. The reason for this is obvious, when we remember that only two per cent. of the brain is composed of nervous tissue. The rest is made up of the cells of supporting tissue, of blood-vessels, and of fluid. The real anatomical basis of intelligence, without doubt, is found only in the strictly nervous tissue of the brain cortex.

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[7] Spitzka, "A Study of the Brains of Six Eminent Scientists." *Transactions of the American Philosophical Society,* 1907. In this paper are gathered together all previous data on the brain-weights of eminent men.

In the study of the relation between the microscopic structure of the cortex and intelligence, efforts have centered on determining the difference between the normal brain and that of the feeble-minded person. One of the earliest investigations, as well as one of the most careful and elaborate, is that of Hammarberg. This Swedish scientist, who died at an early age and before his great work[8] was published, made careful microscopic studies of the brains of normal and feeble-minded persons, concerning whose intelligence during life he had fairly accurate data. His drawings, some of which are reproduced in figure No. 5, show only the cell bodies, and not the cell fibres. They clearly demonstrate the striking correspondence between mental deficiency and deficiency in the number and size of the cell bodies.

The drawings represent for both normal and feeble-minded individuals the appearance of thin sections of the cortex as seen under the microscope. Sections *Ia, IIa,* and *IIIa,* are from three different localities in the cortex of a normal man, a merchant, who died from abdominal typhoid at the age of twenty-eight. Beside each of these sections are sections of the same localities from the brains of feeble-minded individuals. Section *Ib* shows the cor-

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[8] "Studien über Klinik und Pathologie der Idiotie," 1895.

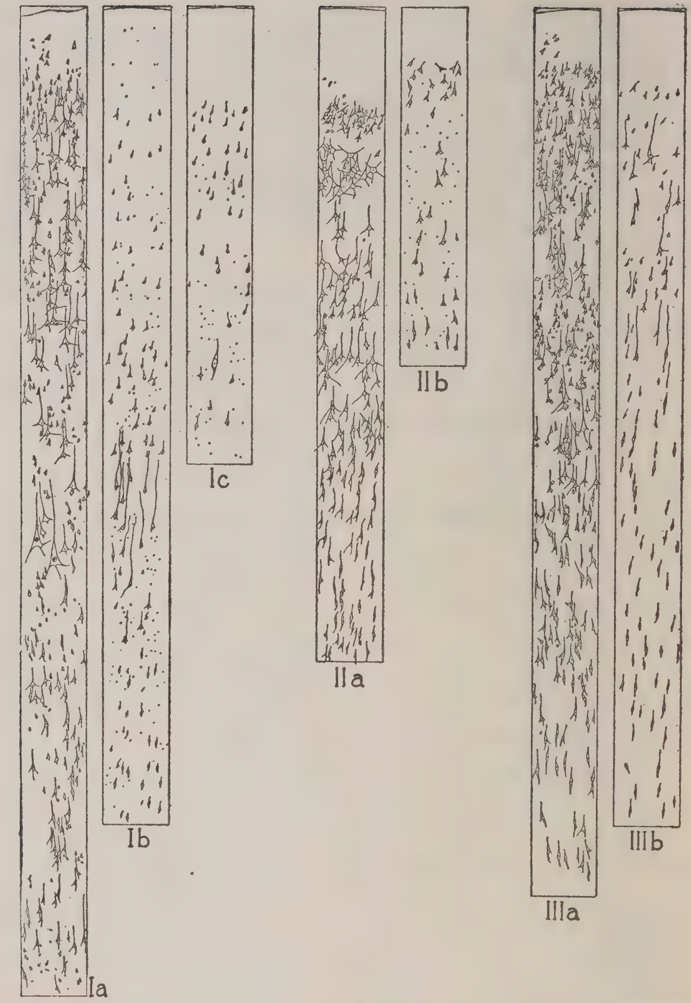
Ia
Ib
Ic
IIa
IIb
IIIa
IIIb

FIG. 5.—Comparison of sections of the cortex of normal and feeble-minded persons, by drawings of the cell-bodies (after Hammarberg). *Ia*, *IIa*, *IIIa*, normal; *Ib*, imbecile; *Ic*, *IIb*, *IIIb*, idiot.

tex of an imbecile, aged one year and ten months, and *Ic* that of a twenty-two-months-old idiot, in the same cortical region as that represented in section *Ia*. The section of the imbecile brain, *Ib,* according to Hammarberg, resembles that of a normal child during the first year of his life. That of the idiot, *Ic,* corresponds in development to that of a normal child between the sixth fœtal month and the beginning of the first year of life. Sections *IIb* and *IIIb* are taken from the same localities of the brains of idiots as *IIa* and *IIIa.* Section *IIb* is from the same brain as *Ic.* Section *IIIb* is from the cortex of an idiot who died at the age of fourteen. The greatest portion of this cortex, Hammarberg states, was not more developed than the normal cortex in the last part of embryonic life.

It has been noted by Bolton and others that the cells of the feeble-minded cortex are undeveloped.[9] Their small size and the great scarcity of their fibrous branches show this. In the pyramidal layer, the cells, though well outlined, are lacking in angles, and so appear globular and poorly formed. Such poorly formed cells may be found in all parts of the cerebral cortex, but they are most frequent in the anterior part of the frontal lobe. Similar cells were noted by Bevan Lewis in the cortex of the ape. Since the lack of development of the cells involves a scarcity of fibrous branches, or association fibres, it follows that in the feeble-minded cortex there is a marked shrinkage in the bands of association fibres. Indeed, it is quite possible that the scarcity of fibres rather than the underdevelopment of the cell bodies is the fundamental cause of mental weakness. The underdevelopment of the fibres and of the cell body are, however, both parts of the general underdevelopment of the cells as a whole, and both are most obvious in the front part of the brain. According to Bolton it is only in this frontal region that the degree of underdevelopment varies strictly in accordance with the grade of feeble-mindedness.

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[9] J. S. Bolton, "The Brain in Health and Disease," 1914, pp. 79–99.

Bolton believes that differences in the intelligence of normal individuals are due to variation in the same cortical features as those by which feeble-mindedness is so clearly shown. "As a final remark," he writes, "I would add that there is reason to believe that this physical basis of the cerebral functions . . . exhibits equally important though less extensive variations in the cases of presumably normal individuals; and thus indicates the likelihood of a structural origin for individual differences in mental endowment."[10] This opinion is unquestionably sound. It being established that an underdeveloped cortex is the cause of feeble-mindedness, it is safe, even in the absence of post-mortem examinations, to conclude that it is the degree of development of the cortex which determines the degree of intelligence of any individual.

Aside from the deficiencies revealed by the microscope in the brains of the feeble-minded, there often exist gross defects of structure of such a severe and extensive nature as to be obvious to the naked eye. Important structures may be entirely absent. There may exist great divergencies from the normal configuration of the cortical folds or convolutions and the fissures between them. The convolutions are likely to be fewer in number and less complex, so that the brain presents a simpler and smoother appearance. Often the cortex is reduced in thickness. Great bands of association fibres running beneath the cortex may be entirely absent. I once sectioned an idiot's brain in which the great band of association fibres connecting the two cerebral hemispheres was almost entirely absent. The cortex itself was very much thinner than in the normal brain. In the small headed cases, called microcephalic, such as are sometimes exhibited in "side-shows" as the "last of the Aztecs," the brain cortex is greatly reduced in area. These specimens, as a rule, show a narrow, rapidly receding forehead which corresponds to the underdevelopment of the temporal and frontal lobes. In the back part of their brains, however, the insufficiency in the amount of cerebral cortex is still more noticeable.

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[10] *Op. cit.*, p. 99.

Although these gross malformations of the brain are frequently associated with the more serious degrees of mental deficiency, they are not so important as the defects that can be seen only by the aid of the microscope, and they should not be regarded as the essential basis of imperfect mental development. There are many instances on record in which just such gross malformations have existed in individuals whose mental condition was apparently normal.[11] It is now established beyond all doubt that the really essential basis of defective mentality is defective development of the cerebral neurones. "Whatever may be the relation of mind to brain," writes Tredgold, "it is now fully recognized that the manifestation of mental activity is indissolubly connected with the cells of the cerebral cortex. Mind develops *pari passu* with their growth, and fails with their decay. Dementia is coincident with their degeneration and death, and amentia (feeble-mindedness) is associated with their incomplete development."[12]

Summing up, then, the salient points concerning the relationship between brain development and intelligence, through the evolution of the lower animals and the growth of the human being, we find Nature utilizing throughout the same fundamental principles. Thus, in all strata of development, the correspondence depends to some extent upon brain-weight, but mainly upon the complexity of structure displayed by the cerebral cortex. In animals and people, advancement in intelligence is accompanied by increased number and improved size and structure of the pyramidal cells, with richness of connecting fibres. The chief fact to be carried from this part of the discussion to the perusal of succeeding chapters, is that the mentality of a child is based, primarily, upon the development of his cerebral neurones.

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[11] See Tredgold, "Mental Deficiency," 2d ed., p. 74.

[12] *Op. cit.*, p. 73.

CHAPTER V

PHYSICAL DEFECTS

The Relation of Physical Defects to Intelligence.—I have discussed the relation of intelligence to brain development somewhat in detail because it is fundamental. But the development of the brain does not occur independently of the rest of the physical being. The brain, like all parts of the body, is dependent for its nutrition upon the food we eat and the air we breathe, and so is dependent upon the processes of digestion and of respiration. And for the nervous currents which stimulate it to action, the brain is dependent upon the sense organs and the nerves which connect it with them. In turn, the brain exerts a far-reaching control over the body. It controls the movement of the muscles in the execution of acts, and it exerts a powerful influence over many of the internal bodily processes, such as those of secretion, digestion, circulation and respiration. Not only is the brain connected with the rest of the body through this mutual dependence of functions, but also through the fact of a common origin. All parts of the body develop from the same germ cells. It is therefore not surprising to find that many bodily defects are very frequent in mentally retarded children, and that, on the other hand, a well-developed body is something of an index of intelligence as well as an aid to its development.

The correlation between intelligence and physical defects is not so close, however, as many people have supposed. Ayres conducted an investigation in New York City to determine the relation between the degree of mental development as shown by school attainments and such defects as adenoids, enlarged tonsils and glands, defective teeth, poor vision, and poor hearing.[1] The children were divided into two groups, normal and retarded. Those who were in the grade they should have been in, had they entered school at the age of six or seven and progressed at the rate of one grade per year, were called normal, and those who were behind their grade were called retarded. The comparison was thus between the older children in a grade, the retarded ones, and their younger classmates, the normal ones. The outcome was that the percentage having physical defects was larger for the normal children than for those who were retarded!

In order to find an explanation of this unexpected result, Ayres retabulated his data, classifying all the children by their ages instead of by their school grade. It thereupon appeared that there exists a steady decrease from the age of six up to the age of fifteen in the percentage of children having each sort of defect, with the exception of bad vision. This explains the presence of more physical defects among the normal children than among the retarded. The normal children were younger than the retarded children of the same grade with whom they were compared, and consequently showed more defects.

Ayres, still using the same data, proceeded to make a comparison, not between normal and retarded children in the same grade, but, for children of each age, between those of higher and lower grades, thus eliminating the influence of age upon the comparison. Children of the same age were divided into superior, normal and dull, according to whether they were advanced, average, or retarded in their school grade.

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[1] Ayres, "Laggards in Our Schools," 1909, pp. 117–132.

It then appeared that the percentage having physical defects was larger for the dull children than for the superior. The difference in the percentages of physically defective children in the three classes—dull, normal and superior—was slight, but the difference in the *degree* of defectiveness was found to be rather marked, the dull child showing on the average considerably more defects than the superior one. Ayres' investigation shows, then, that in general dull children are more likely to have physical defects than are superior ones, and that the defects in the dull child tend to be more numerous and more serious than those in the superior child; but it also brings out the fact that the difference between dull and superior children, so far as physical defects are concerned, is less than that between younger and older children.

Now, although the degree of correspondence between intelligence and freedom from physical defects is slight, physical defects exert a marked influence upon the activity of intelligence. A child with physical defects may be either superior or dull; but, whichever he is, the removal of his physical defects will help him mentally. Physical defects, of little importance as causes of poor intelligence, and only in small part due to the same factors as dullness, nevertheless constitute a severe handicap to efficient mental activity, causing the child to do his mental labor under difficulties. They affect intelligence somewhat as hampering clothing does the efficient exercise of physical strength. There might be only a slight correlation between the weight or fit of a child's shoes and the strength of his legs; yet a child with sufficiently heavy and misfitting shoes would certainly be handicapped in a foot-race.

The proper treatment of physical defects is an important educational measure, a measure that enables the child to make the best use of his abilities. Removal of a child's adenoids, or the provision of proper eye-glasses, may be of greater importance to his mental achievements than the difference between the best and worst of school teaching. I may say that the presence of remedial physical defects in an apparently dull child is an almost hopeful sign; it allows his parents to believe that his dullness is only apparent—that his intelligence is normal but handicapped. There are many striking cases on record of improvement in a child's school work as the result of the removal of adenoids or tonsils, or the fitting of glasses, followed by special, individual teaching.[2]

The account here given of sensory and other defects is limited to the minimum that is compatible with a broad understanding of the educational needs of children. I shall point out merely how the presence of the commoner defects, particularly those of vision and hearing, may be ascertained and indicate some of the chief consequences.

Defective Vision.—Visual acuity, or the ability to see, is ordinarily tested by having the child read letters at a distance. These letters are printed in nine lines on a chart, the letters of each line being smaller than those of the line above it. Such a chart is commonly known as a Snellen test card, and may be procured from any oculist. Usually the top line contains just one letter, which is of a size ordinarily distinguishable at a distance of 200 feet.

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[2] See Witmer, "The Treatment and Cure of a Case of Mental and Moral Deficiency," *Psychological Clinic,* vol. ii, 1908, p. 153; and Smith, "Sixty-two Days' Training of a Backward Boy," *Psychological Clinic,* vol. ii, pp. 5, 29 and 134.

The next line of letters is large enough so that it may normally be read at 100 feet, the next at 70 feet, and so on down. The line next to the bottom is usually one that should be read at 20 feet, and the bottom line one that can be read only at 12 feet. The distance at which each line ought to be read is printed beside it on the test card.

To test a child's vision, this card is hung on the wall in a good light a distance of 20 feet in front of the child. The child reads the letters as the teacher points them out, beginning at the top line and going down to a line where he misses more than one letter. The result of the test is recorded as a fraction, of which the numerator is the distance at which the child is standing from the chart and the denominator the distance at which the smallest line he can read should be legible, as indicated by the distance printed beside it. Thus, if a child, standing at the standard distance of 20 feet from the chart, can read all the letters of the 20-feet line, or all but one of them, with his right eye, but can read only those of the 40-feet line with his left, the vision of his right eye is $\frac{20}{20}$, or normal, while that of his left eye is $\frac{20}{40}$, or one-half. Each eye must be tested separately, and the eye not being tested kept open, but covered by a card held close in front of it.

Visual acuity of ¾ to ½ is not regarded as particularly bad. The percentage of children having various degrees of defective vision varies greatly from class to class. On the average, results something like the following may be expected: A visual acuity in one or both eyes of ⅓ or worse in 6 or 8 per cent.; of ½ or worse, in 10 to 15 per cent.; of ⅔ or worse, in 15 to 35 per cent.

The test for visual acuity detects all those who have defective vision at the distance of twenty feet; but it misses many whose vision is very poor at the ordinary reading distance. It cannot be counted upon to detect those who are suffering from one of the commonest as well as most serious visual defects, namely, far-sightedness. The reason is not hard to understand. The far-sighted person sees as well at a distance as the possessor of normal vision; he is merely unable to see clearly objects which are close at hand. At a distance as great as twenty feet, the far-sighted person may see as easily as anybody else, and if he cannot see as easily, he can yet manage to see as well, simply by straining his eyes a little. He may even succeed in reading at the ordinary distance—but only by straining his eyes to a very excessive and injurious degree. Such a person suffers greatly in using his eyes for reading, for they must work constantly under an enormous strain. Clearly, far-sightedness is more serious than near-sightedness. The near-sighted pupil cannot read well at a distance of twenty feet but he may not be bothered at all in near work; whereas the far-sighted pupil, who passes the reading test at twenty feet, with little or no eye-strain, may yet be utterly unable to read print close at hand. When we consider that in school children far-sightedness is several times as common as near-sightedness, it is obvious that the Snellen chart test has to be supplemented by one for far-sightedness.

The simplest way of especially testing far-sightedness is to have the child read through a weak convex lens or magnifying glass, or through a pair of spectacles with two diopter lenses,[3] such as may be had from any spectacle dealer. If these convex lenses do *not* make his vision worse, it is likely that the child is far-sighted.

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[3] See Drummond, "An Introduction to School Hygiene," p. 135. A two diopter lens is one of low power, whose focal length is one-half meter.

Even the lens test may fail, if, from habit, the far-sighted child refuses to relax his eyes. It is necessary, therefore, to have the child examined by a specialist whenever there is any reason to suspect that his vision is defective, even though he passes the tests. In this connection, the teacher should be alert to notice the symptoms of eye-strain in her pupils. These symptoms consist in an aching or tiring of the eyes with prolonged reading, smarting or itching, and a blurring or running together of the letters. Frequent headaches are in themselves a sufficient symptom. According to Cornell,[4] "the only considerable cause of *habitual* headache in children is eye-strain."

It is not sufficient that children suffering from defective vision receive proper examination and treatment by an oculist. When glasses are prescribed, the teacher must see to it that they are worn. The child should be impressed by the notion of their value. Spectacles are a great invention, due, it is said, to Salvino d'Armati of Florence, who died in 1317. At one time, the cost of a pair of glasses, was equal to 50 to 100 dollars, and even if they cost that to-day they would be cheap at the price—as one may perceive by considering the earning ability of those men who, but for their glasses, would hardly be self-supporting. Besides making sure that children wear their glasses, the teacher should guard against glasses that are not properly fitted. She can do this by watching carefully for symptoms of eye-strain. Vision may change. There is a tendency for far-sightedness to diminish and for near-sightedness to increase as children grow older; so that it is necessary from time to time to have the eyes examined, even though they may be already fitted with glasses. Various eye defects, frequently associated with defective vision, should not go unobserved. Styes, squints and swollen or reddened eyelids are readily noted; but in addition the teacher should watch for children who have a tense facial expression and a tendency to screw up their eyes when looking at the blackboard, who hold their books close to their eyes, or stoop down close to their work, or who show excessive blinking and over-sensitivity to light.

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[4] "Health and Medical Inspection of School Children," 1912, p. 221.

Defective Hearing.—Almost as important as defects of vision are those of hearing. They affect in the neighborhood of five per cent. of all children, and are often attended with serious results. Besides his direct loss, a child with defective hearing may suffer a number of indirect bad consequences. Speech is likely to be peculiar, as the mutism that accompanies total deafness indicates. The continual leaning forward to hear may cause stoop shoulders and flat chest, and these, in turn, increase a liability to tuberculosis. Inattention may become pronounced, merely because of the great effort required to hear, and may lead to an undeserved reputation for dullness. Partial isolation from normal play and social intercourse with other children leads to the acquisition of a peculiar temperament, shown in a tendency towards self-analysis and suspiciousness of others. Numerous statistics prove that school work is seriously handicapped by deafness. While children with defective hearing are by no means always retarded, a much larger percentage of such children is found among those who are retarded than among those who are advanced. To some extent this may be accounted for by the association of deafness with other defects, such as adenoids and even with dullness itself. It is for the most part, however, due directly to the obvious handicap of defective hearing.

Hearing ability may be best examined by what is known as the whisper test. As conducted by Kirkpatrick, a number of children may be tested at the same time. He describes his procedure substantially as follows:[5] The children take seats in three rows, three or four or even five children in a row. They are supplied with pencil and paper and asked to keep their eyes to the front. The teacher stands to the right, opposite the middle pupil, and pronounces in a low, distinct whisper a series of numbers which they are asked to write after her, one at a time, as in a dictation exercise. After four or five numbers have been given, the children change seats; those in the row nearest the teacher take the seats of those in the farthest row; those in the farthest row move to the middle; and those in the middle move to the nearest row. Then the teacher whispers another series of numbers. The moving is repeated, and the teacher whispers a third series. This completes the test for the right ear—all the children having been tested at three distances, near, far and medium. The left ear is tested in a similar way, the teacher standing to the children's left. She collects the papers and grades them by taking the total number of digits written correctly. The totals for the right ear and left ear are averaged for the class. The hearing ability of each ear for each child is then recorded in the form of a fraction, the denominator of which is the average for the class and the numerator the number of digits correctly written by the individual child. The record shows the acuteness of hearing of each child in comparison with that of his classmates. With this record before her it should not be hard for the teacher to tell which children require the attention of an ear specialist.

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[5] *Psychological Clinic*, 1909, pp. 96, 97.

Defects of hearing must, imperatively, be recognized early in life. Long-standing cases are likely to be rather obstinate. Small children almost never complain on their own initiative of inability to hear, and older children may frequently conceal their infirmity on account of timidity. Such symptoms as mouth-breathing and earache, apparent stupidity, or even slowness or hesitation in executing commands, should be regarded as sufficient to necessitate an examination by the physician. A discharging ear should be given immediate attention. If chronic, it indicates an inflammation of the middle ear, within the skull, which may result in very serious consequences.

Non-sensory Defects.—Among the most frequent of the non-sensory physical defects met with in school children are the following: Defective glands; enlarged tonsils; adenoids, consisting of little swellings which grow in the passageway connecting the nose with the throat and block it up; nasal catarrh and nasal obstructions of one sort or another; stuttering and lisping; malnutrition; defective teeth, particularly frequent in the younger children; nervous disorders; diseases of the heart, lungs, and skin; and diseases or deformities of the skeleton. Many of these troubles can be recognized only by the physician. Note, however, that a number of them are located in the neighborhood of the mouth and throat. For this reason, a teacher should be familiar with the normal appearance of this region. "Look into the children's mouths" is good pedagogy and sound psychology. It stands for the principle of careful individual observation of children, a principle which one must follow if he is to guide children successfully in their mental development.

The removal of adenoids and of tonsils is not infrequently accompanied by a marked improvement in general health and a decrease in susceptibility to colds and sore throat. Marked improvement in mental ability may also result. A number of studies indicate that children who are retarded in school may do better work after the removal of these sources of infection. In fact, the majority of all cases of sudden improvement in mentality are those in which adenoids or tonsils have been removed. Removal of adenoids may lead to a much improved facial expression, by permitting the child to breathe through his nose instead of a wide-open mouth. It may also result in better attention by removing the distraction caused by mouth-breathing. When the adenoids have been responsible, as they sometimes are, for catarrh in the ear, their removal may result in improvement in hearing. However, in numerous cases, no mental improvement at all follows. In an investigation of the effects brought about by removal of adenoids in a group of children retarded in their school work, Cornell found that according to the opinion of the teachers a considerable number were not benefited mentally, and that the entire group received 52 failures to 32 promotions during the year after the operation.[6]

Stigmata of Degeneracy.—Before leaving the subject of physical defects, I must mention the so-called "stigmata of degeneracy." These have been widely discussed and have attracted a great deal of notoriety as signs of criminality, insanity, and feeble-mindedness. Certain defects have been given this name on the theory that they originate in defects in the germ cells from which the individual develops. Needless to say, it is often extremely difficult to decide whether a physical defect owes its origin to defective germ plasm or not; and it is consequently not surprising that there exists great disagreement between authorities as to what should be enumerated as stigmata of degeneracy. Almost every deviation from the normal has been included by some writer or other; and there is no list that does not include defects that may not be due to other factors than defective germ plasm.

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[6] "Health and Medical Inspection of School Children," 1912, pp. 276–278.

The following list is perhaps fairly representative:

1. Undersized or misshaped head.
2. Defective height and weight.
3. Misshaped ears: Peculiarities of form and size of the external ear and its various parts.
4. Deformities connected with the eyes: Crossed eyes; nystagmus, a rapid movement of the eyes from side to side, especially noticeable when the child tries to fixate an object lying in a new direction; small, oblique opening between the eyelids, etc.
5. Nose, lips and palate: Peculiarities of size and form; slavering; protruding jaw; small and receding jaw; adenoids.
6. Teeth: Irregularities of position, number, form and size; delay in appearance of either temporary or permanent teeth.
7. Defective circulation and respiration.
8. Defects of the alimentary or digestive system.
9. Hair: Its absence from customary places or its presence in unusual places.
10. Defective facial expression.

Now any of the above defects may appear in persons who are otherwise perfectly normal. Nevertheless, they are far more numerous in persons of a degenerate type, especially the feeble-minded. In an examination of two hundred morons, Lapage found stigmata in all but nineteen, and, not uncommonly, three or more stigmata in the same individual. They are more numerous in imbeciles and idiots, than in morons. Clouston found deformed palates in nineteen per cent. of the ordinary population, but in sixty-one per cent. of idiots. It is now fairly well established that there exists a rough correlation between the number, severity and extensiveness of stigmata and innate defectiveness of the central nervous system.[7] One or even two of these stigmata may be of no particular importance; but if they are more numerous, they are significant.

By themselves, stigmata of degeneracy should never be taken as evidence of dullness or feeble-mindedness. They are quite too unreliable. They have significance only in those cases in which, as the result of mental tests or other observations, mental subnormality is already known to exist. In these cases, stigmata have some significance as regards the *cause* of the mental subnormality. The stigmata, while never conclusive, are a sign of defectiveness in the germ cells from which the child has developed. When, then, the child is already known to be retarded, the presence of stigmata may be regarded as evidence that his retardation is inborn, that it is dullness rather than mere backwardness, that it is not due to temporary causes which may be either easily remedied or outgrown, but that on the contrary it is an ingrained, permanent feature of his constitution.

All in all, soundness of body is correlated with soundness of mind. With regard to any other part of the body than the central nervous system, however, the correlation is so slight that all our elaborate measurements scarcely do more than establish its existence. In the case of the central nervous system, there is abundant evidence of a very high correlation, particularly with certain features of the cerebral cortex. Here, owing to the difficulty of access, we are still greatly in need of more precise data. Enough is known, however, so that we may be confident that brightness is much more highly correlated with the number and development of the cortical cells than with any other bodily features. The correlation is at least so high, that, in the absence of any information concerning a child except that he is superior or dull, we may assume as the most probable cause of his mental condition the state of his cerebral cortex.

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[7] Bösbauer, Miklas und Schiner, "Handbuch der Schwachsinnigenfürsorge," 1909, p. 30.

Medical Inspection and Its Relation to the Teacher.— In concluding this chapter on physical defects, I shall add a few comments on medical inspection and its relation to the teacher. To some people, who greatly exaggerated the connection between physical defects and mentality, the results of medical inspection have been a disappointment. They were disappointed to observe that children still continued as usual to fail in school work in large numbers. To those who better understood the true relationship between mind and body, medical inspection appeared not only successful but indispensable. In the United States, medical inspection has had to fight against considerable prejudice. Its desirability, however, is beyond debate; the only problem, now, is how to make it more efficient. In the solution of this problem, a great deal depends upon the coöperation of the teacher.

Medical inspection is now nearly a century old. It originated in France, where, in 1837, a royal ordinance made it the special duty of the female supervisors of kindergartens to watch over the health of the children.

It is now well-nigh universal. Medical inspection has been adopted by all the nations of Europe as well as in many other parts of the world. The Argentine Republic is said to have one of the most thorough systems of medical inspection in existence; and Japan has a system which embraces the entire empire, including the most remote rural districts.[8] In the United States, since the inception of the movement in Boston in 1894, its expansion has been very rapid.

Medical inspection has a twofold aim: First, the detection of communicable diseases, which has as its main object the protection of the community; and, second, physical examination, which aims to discover defects and diseases, and to note the general physical condition of children. In both these aims the coöperation of the teacher is invaluable. The teacher should be familiar with the symptoms of infectious diseases,[9] and constantly on the watch for them. In the physical examination, also, the teacher may coöperate by testing vision and hearing and by looking out for other physical defects. In some states, teachers are required by law to make tests of the vision and hearing of their pupils. Even in cities which have an adequate system of medical inspection, it is desirable, even though not required, that the teachers should be able to make such tests. The object, of course, is not to arrive at a diagnosis of causes, but merely to determine whether vision or hearing is defective, so that a thorough examination and proper treatment may be given by a specialist and so that the teacher herself may arrange for proper seating and methods of instruction.

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[8] See Gulick and Ayres, "Medical Inspection of Schools," 1908, pp. 18–26.

[9] A convenient description of these is given by Lapage, "Feeble-Mindedness in Children of School Age," 1911, pp. 168–178.

The greatest of all the teacher's responsibilities, however, in connection with the physical welfare of her pupils, is in the follow-up work that is necessary if medical inspection is to be made successful. Parental indifference and neglect is, at present, the greatest obstacle to the success of medical inspection. In a great many cases it is very difficult, if not impossible, to persuade parents to act upon the notification received from the medical examiner. The medical examiner himself can not remedy the defects he finds. His duty ends when he has notified the child's parents of the existence of defects; he is not permitted to correct them. However unsatisfactory this state of affairs may be, it will probably continue for a long time to come. In the meantime, follow-up work is clearly necessary, unless a large part of the medical inspector's labor is to be wasted.

Sometimes it is made the special duty of the school nurse to see to it that proper measures are taken for the correction or treatment of physical defects; but the responsibility of the teacher is never entirely removed. If the school is fortunate enough to possess an efficient school nurse, it may never be necessary for the teacher to deal directly with the child's parents. All that may be required of her is strict insistence against neglect. In less fortunate circumstances, the teacher must take more active measures. The teacher, by virtue of her position of direct authority over the education of children entrusted to her care, must hold herself responsible for the proper treatment of every remedial physical defect present in her pupils. The correction of physical defects is as much an educational measure as the correction of illiteracy. The teacher must accept the responsibility for both, whether or not the administrative authorities ask her to do so.

CHAPTER VI

ANATOMICAL AGE

The Various Child Ages.—According to psychology, every child has a number of different ages, each of which represents an appraisement of some one of the factors comprising his complex existence. The four most important are the chronological, mental, pedagogical and physiological, or anatomical, ages.

Each of these ages has different implications. The chronological tells only how long the child has lived. The mental age states his amount of intelligence. The pedagogical age gives his school grade. It is merely a subdivision of what may be termed his acquisitional age, the age which tells how much he has acquired in the way of information and serviceable habits. His physiological age records the extent to which his bodily functions have developed. It is distinguishable from anatomical age, which expresses the stage of growth of the bodily structures, but physiological and anatomical age are so closely related that for educational purposes they may be united under the head of anatomical age.

Each of these ages is to a large extent independent of the others. We have already seen that a child's mental age may be far beyond or behind his chronological age. Likewise, pedagogical age and anatomical age may differ widely from chronological age. Pedagogical age, which refers to a child's school grade, might be supposed inseparable from mental age, but, unfortunately, it does not always prove to be so. The grade a child attains in school depends upon his age at entering, upon the flexibility of the grading system to which he is subjected and other factors, as well as upon his intelligence. Pedagogical age and mental age not only differ from each other, but are both quite distinct from anatomical age. This distinction is most striking in idiots and imbeciles, who may be fairly well developed physically and yet possess practically nothing of intelligence or information.

While the various ages are distinct and to a certain extent independent, their true significance is clear only when they are considered in relation to each other. To know a child's mental age, for example, is of comparatively little value, unless his chronological age is also known. If, however, we know the relation of the former to the latter, we can form some idea of the child's brightness, to some extent can predict his future, and begin to plan his education with some measure of wisdom. Thus considered in relation to the other ages of the child, both the anatomical and pedagogical age contribute immensely to the understanding of the child's nature—his needs and his potentialities.

Anatomical Age.—The measurement of any of these ages, except the chronological, requires that norms or standards be first established, because the measurement is made by applying a scale showing the attainments of normal children at each of the chronological ages. Thus, as heretofore stated, a child has the mental age ten if he manifests the amount of intelligence of an average ten-year-old child; so that mental age may be defined as that degree of intelligence shown by an average child of the corresponding chronological age. Anatomical age is defined and measured in a similar manner. It is an age which represents the degree of physical development attained by the average child of the corresponding chronological age. If a child has not attained the anatomical development of normal children of his own chronological age, he is anatomically retarded; if he has attained a stage reached on the average only by children older than himself, he is anatomically advanced.

By the stage of a child's physical development is meant neither his health, nor his strength, nor even his size, but simply the point at which he has arrived in that series of changes by which the body of a child is transformed into that of an adult. It is well known that the development of the body is marked by numerous definite changes in the structure of its parts, and that in all persons a certain condition is finally reached which marks the end of these changes. For example, everyone acquires a certain number of teeth and no more. We know that a child who has only one or two of his permanent teeth has a larger number of stages still to traverse than has the child who has already four or five of his permanent teeth, and a much smaller number of stages yet before him than has the child who has not acquired any permanent teeth. When all the teeth have appeared, anatomical development with respect to teeth is complete, no matter whether the teeth are good or bad, and no matter whether the child's body is large or small, strong or weak. It is clear that stages of this sort are quite different from such things as strength or height. When a boy has two permanent teeth, we know how many more he will eventually possess; whereas when he has reached four feet in height, we do not know how much more he is to grow. We know the height of the average man, but we do not know the height any particular boy will attain when he becomes a man. Perhaps we can estimate what his final height will be, but his actual height does not directly represent a definite stage in a known series of developmental changes, leading to a known final stage, as does the number of teeth.

Both mental and anatomical ages measure something in the child by comparison with the attainments of normal children; but they differ in a very important respect, apart from the fact that one measures something mental and the other something physical. This difference has often been overlooked with the result that great confusion has existed concerning the use to be made of the knowledge of a child's anatomical age. The word *age* has a quite different meaning in the two cases. In mental age, the term indicates an amount, in anatomical age, a proportion. Mental age tells us how much intelligence the child has; it does not tell us what proportion of his final intelligence he already possesses. Anatomical age, on the other hand, does not indicate the amount of physical development, but merely the proportion of the final development reached at a given period. Of course it does not give this proportion directly in the form of a fraction; but it does give directly the *stage* reached in a known series of stages. We know what stages have gone before and what remain to be traversed.

The Indices of Anatomical Age.—To the question, then, what is the best way to determine a child's anatomical age, different answers have been given. In the main, reliance has been placed on one or the other of three indices. Dr. Bean emphasizes the value of the eruption of the permanent teeth as a measure of anatomical age.[1] Dr. Crampton, who, while assistant director of physical training in the public schools of New York City, was one of the first to call attention to the importance of a knowledge of anatomical age, uses the onset of puberty as a sign.[2] Dr. Rotch and others have argued that the most reliable index of anatomical age is the degree of development of the skeleton.[3] Dr. Rotch and Dr. Pryor [4] have established the fact that the degree of skeletal development may be used with a high degree of accuracy at all ages from birth to maturity, as an index of anatomical age.

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[1] "The Eruption of the Teeth as a Physiological Standard for Testing Development." *Pedagogical Seminary,* vol. xxi, 1914, pp. 596–614.

The Eruption of Teeth.—The most convenient means of determining anatomical age is afforded by the eruption of the teeth. The teeth can be counted and identified by almost anyone, after a little experience; consequently, their use as measures of anatomical age does not call for much interpretative ability! Some students of anatomical age regard dentition as the best single indicator, particularly at the earlier school ages.[5]

From the age of entering school until the age of twelve, a child's anatomical age can be fixed within quite narrow limits solely by inspection of his teeth. The first permanent teeth are the lower molars. These normally appear at the age of six. They appear just behind the rearmost temporary teeth, and thus, counting from the middle line of the front of the mouth, occupy the sixth place. Their position in the mouth as well as that of the other teeth is shown in the accompanying figure, No. 6.

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[2] "Anatomical or Physiological Age Versus Chronological Age," *Pedagogical Seminary,* vol. xv, 1908, pp. 230–237; and "Physiological Age," *American Physical Education Review,* vol. xiii, 1908, pp. 141–154, 214–227, 268–283, and 345–358.

[3] "Röntgen-ray Methods Applied to the Grading of Early Life." *American Physical Education Review,* vol. xv, 1910, pp. 396–420.

[4] *Bulletins of the State College of Kentucky:* 1905, "Development of the Bones of the Hand," pp. 30; 1906, "Ossification of the Epiphyses of the Hand," pp. 35; 1908, "The Chronology and Order of Ossification of the Bones of the Human Carpus, pp. 24.

[5] See Beik, "Physiological Age and School Entrance." *Pedagogical Seminary,* vol. xx, 1913, p. 302. On the desirability of using both dental and skeletal development, see Lowell and Woodrow, "Some Data on Anatomical Age and Its Relation to Intelligence," *Pedagogical Seminary,* vol. xxix, 1922, p. 11.

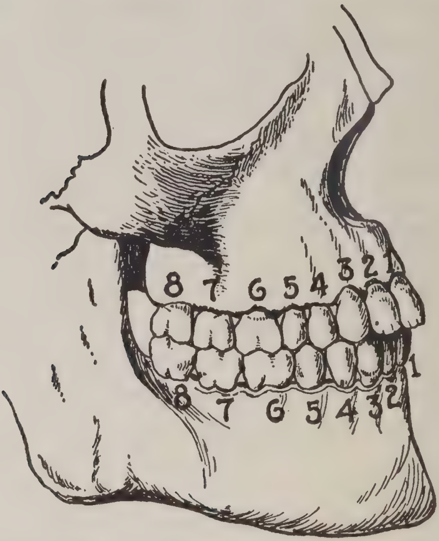

FIG. 6.—The permanent teeth (after Testut and Jacob, "Traité d'anatomie topographique," vol. i, 1909, p. 266). 1, 1, central incisors; 2, 2, lateral incisors; 3, 3, canines; 4, 4, first premolars; 5, 5, second premolars; 6, 6, first molars; 7, 7, second molars; 8, 8, third molars (wisdom teeth).

About six months after the first molars come the two lower central incisors. The remaining teeth appear in regular order from the front backwards, except that the first premolars may erupt before the lower canines, and both the first and second premolars before the upper canines.

The normal age of eruption for any tooth varies. Part of this variation is due to race and sex differences. The teeth of French children mature more rapidly, and those of German children less rapidly than those of American children.[6] Girls acquire their teeth earlier than do boys. But even in individuals of the same race and sex, there is a considerable variation in the age of eruption of the teeth, and on this account, it is not altogether easy to construct a normal scale. However, sufficiently extensive investigations have been made that it is possible to state within a month or so at what age one-half of all children possess a given tooth. This age is relatively the normal age. If, then, a child's teeth erupt at the chronological ages indicated in the following table as

TABLE SHOWING THE AGE OF ERUPTION OF THE PERMANENT TEETH*
A SCALE FOR MEASURING ANATOMICAL AGE

Name of tooth	Normal age (present in 50 per cent.)	Present in 25 per cent. of children	Present in 75 per cent. of children
Lower first molar........	6 yrs. 0 mos.	5 yrs. 6 mos.	6 yrs. 6 mos.
Upper first molar........	6 yrs. 3 mos.	5 yrs. 9 mos.	7 yrs. 0 mos.
Lower central incisors...	6 yrs. 6 mos.	6 yrs. 0 mos.	7 yrs. 0 mos.
Upper central incisors...	7 yrs. 6 mos.	7 yrs. 0 mos.	8 yrs. 3 mos.
Lower lateral incisors....	7 yrs. 6 mos.	7 yrs. 0 mos.	8 yrs. 6 mos.
Upper lateral incisors....	8 yrs. 6 mos.	8 yrs. 0 mos.	9 yrs. 3 mos.
Upper first premolars....	10 yrs. 0 mos.	8 yrs. 9 mos.	10 yrs. 9 mos.
Lower first premolars....	10 yrs. 6 mos.	9 yrs. 6 mos.	11 yrs. 9 mos.
Lower canines..........	10 yrs. 6 mos.	9 yrs. 9 mos.	12 yrs. 3 mos.
Upper second premolars..	11 yrs. 0 mos.	9 yrs. 9 mos.	12 yrs. 0 mos.
Lower second premolars..	11 yrs. 6 mos.	10 yrs. 3 mos.	12 yrs. 6 mos.
Upper canines..........	11 yrs. 9 mos.	10 yrs. 9 mos.	12 yrs. 9 mos.
Lower second molars....	11 yrs. 9 mos.	10 yrs. 9 mos.	14 yrs. 0 mos.
Upper second molars....	12 yrs. 6 mos.	11 yrs. 6 mos.	14 yrs. 3 mos.
Third molars..........	17th to 24th year		

* This table is based mainly on the data of James and Pitts. "Some Notes on the Dates of Eruption of 4,850 Children, Ages under Twelve," *Proceedings of the Royal Society of Medicine*, vol. v, 1912. It agrees substantially with the data of Bean on dentition in American school children.

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[6] Bean, *op. cit.*, pp. 603–605.

normal, he is normal in anatomical age; if his teeth erupt at a later age, he is anatomically retarded, and if at an earlier age, anatomically advanced. The table does not give different norms for the different sexes, for it is desirable to have one standard for both sexes, just as in the scale for measuring intelligence. Then, by applying the same standard of anatomical development to each sex, the difference between the sexes can easily be measured.

The Ossification of the Wrist Bones.—The stage of skeletal development is best judged by the bones of the wrist. The wrist contains eight small bones, the carpal bones, the development of each of which, from cartilage into bone, occurs at a different age. The change from cartilage to bone, known as ossification, is readily followed by means of Röntgen ray photographs. The first ossification, that of the *os magnum,* occurs towards the end of the first year of life, and the last, that of the *pisiform* bone, occurs normally during the eleventh year. The ossification of the other wrist bones is distributed over the intermediate years.

In addition to the stages formed by the development of the wrist bones, there are others, marked by certain changes in the wrist end of the bones of the forearm, the *ulna* and the *radius.* The ossification of a bone such as the ulna or the radius begins in its middle portion, or shaft. The shaft grows in length by an extended ossification of the cartilage towards both ends. While the shaft is thus growing towards the ends of the bone, ossification begins at new starting points in the ends and progresses towards the centre. Thus at one stage in the formation of a bone like those of the forearm, the shaft is separated from the ends of the bone by a zone of cartilage. The shaft and the ends, the latter known as *epiphyses,* continue to grow towards each other until there is a complete bony union.

The different stages of development of the ends, or epiphyses of the ulna and radius form a valuable supplement to the scale of anatomical age afforded by the development of the wrist bones. The development of the end of the ulna is particularly valuable, because complete bony union with the shaft is not established until long after the last of the wrist bones has ossified. Additional information concerning anatomical age may sometimes be gained by studying the degree of development shown by the ends of the bones in the palm of the hand, and in the fingers and thumb. All the bones of the hand and wrist, as well as the ends of the ulna and radius, are easily included in one radiograph. Consequently, by a single, objective impression, a significant record of a child's anatomical age may be obtained. The record may be taken as often as desired, and at any age from birth to maturity.

Of all the indicators of anatomical age, the stages of development shown by the skeleton and the teeth are the most reliable. The development of the skeleton, in particular, is very little affected by adverse circumstances. This has been shown by several studies on the effect upon the growth of the various bodily organs, brought about by underfeeding of animals. These studies establish the fact that the bones form the most stable part of the body. Dr. Jackson, studying the growth of young white rats, found that the skeleton continues to grow even when, by means of underfeeding, the weight of the body as a whole is kept constant. "The increase in the skeleton during constant body weight," he writes, "appears to involve the ligaments as well as the cartilages and bones. The skeletal growth tends to proceed along the lines of normal development, as indicated by the decrease in water-content and by formation and union of various epiphyses."[7] Like results have been obtained by investigations of the calf, the dog and the cat. Likewise it has been found that malnutrition in children retards growth in length (consequently, skeletal growth) less than growth in body weight, so that the skeleton may continue to grow even while the weight of the body remains practically at a standstill.

Photographs of the wrist bones have been compared with those of other parts of the skeleton, such as the elbow, shoulder, knee, and ankle. The result has been general agreement that the development of the wrist bones affords both the most reliable and the most practical single index of general skeletal development. "It has been determined," writes Rotch, "that the appearance of the carpal bones and the epiphyses of the radius and ulna represent the stage of development of all the other epiphyses throughout the skeleton, so that the bones of the wrist may be relied upon to judge of epiphyseal development without having to take Röntgen pictures of the other epiphyses."[8]

Variation in the Anatomical Age of Children.—I have already pointed out that children of the same chronological age vary enormously in intelligence, or mental age. I have indicated that in an average group of one hundred ten-year-old school children, we may expect to find children of all mental ages from seven to thirteen. Similarly, as is proved by data in the following chapter, in any large school system, ten-year-old children may be found in all grades from the first to the sixth, and this in spite of a certain tendency of the schools to force all children along at a uniform rate. Thus, both in mental age and school grade, ten-year-old children are found distributed over a range equal to that covered by normal children differing by five or six years in chronological age.

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[7] "Changes in the Relative Weights of the Various Parts, Systems and Organs of Young Albino Rats Held at Constant Body Weight by Underfeeding for Various Periods." *Journal of Experimental Zoölogy,* vol. xix, 1915, p. 153.

[8] *Op. cit.,* p. 397.

This variation in the mental ability of ten-year-old children, large as it is, is almost equalled by that in anatomical age. Measured by whatever index, the anatomical ages of ten-year-old children distribute themselves over a distance which it takes the average child five or six years to traverse. Such great deviations from normal make it highly important that anatomical age be taken into consideration in estimating the child's potentialities. Without a knowledge of a child's anatomical age, we cannot properly appraise his mental ability. I have stated that mental age has significance only when compared with chronological age. It acquires additional significance, however, when compared with anatomical age. It is consequently well to realize how greatly children of the same chronological age vary in anatomical age. I shall give illustrations of the extent of this variation in the case of all three of the commonly used indices—dentition, pubescence, and ossification of the wrist bones.

In the table showing the age of eruption of the various permanent teeth, it is indicated that the chronological age at which a given tooth will erupt in twenty-five per cent. of children is considerably lower than the age which must be reached before it will be present in seventy-five per cent. of them. The difference between the two ages is about one year for the first molars and the incisors, but increases to two years or over for the remaining teeth; so that we may say that with fifty per cent. of children, each tooth makes its appearance during an age interval of one or two years. The total range of ages, however, at which a tooth may appear is much greater than this. The upper central incisors, for example, appear in some children as early as the age of five years and three months. and in others as late as nine years and nine months, thus covering a range of four years and six months. The upper lateral incisors cover a range of over five years, and the upper premolars and canines a range of over six years.

The older the normal age of appearance of a tooth, the greater will be the range of years at which it may appear. This is simply one aspect of the general law that differences between individuals measured in terms of years of development tend to increase as the individuals grow older. Just as a slight difference in mental age at the earlier ages is the equivalent of a large one at the later ages, so does a slight difference in anatomical age at the earlier ages predict a large one at later ages.

In regard to pubescence, Crampton has found that some boys cross this landmark of physical development as early as the age of twelve and a half, while others do not do so before the age of seventeen and a half to eighteen. There is a variation, then, in the male sex alone, of five years. Crampton distinguishes three stages, which he calls the pre-pubescent, the pubescent and the post-pubescent. The percentage of boys which he found in each of these three stages is shown in the following table, covering the ages of twelve and a half to eighteen.[9]

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[9] *Pedagogical Seminary,* vol. xv, 1908, p. 232.

Age of Pubescence in Boys

Age in years	Pre-pubescent (per cent.)	Pubescent (per cent.)	Post-pubescent (per cent.)
12.5–13.0	69	25	6
13.0–13.5	55	26	18
13.5–14.0	41	28	31
14.0–14.5	26	34	40
14.5–15.0	16	24	60
15.0–15.5	9	20	70
15.5–16.0	5	10	85
16.0–16.5	2	4	93
16.5–17.0	1	4	95
17.0–17.5	0	2	98
17.5–18.0	0	0	100

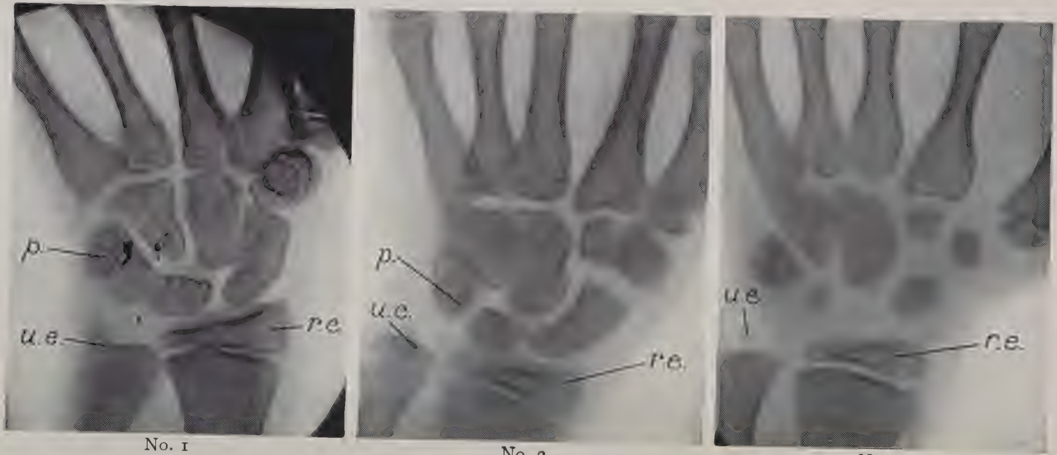
To give an idea of the variation in anatomical age as measured by the development of the carpal bones, I cannot do better than to describe the results of an intensive study of one hundred ten-year-old school children undertaken at my suggestion by Mr. Severson, principal of a grade school in the city of Minneapolis. The Röntgen ray photographs of these ten-year-old children differed so greatly that we found it possible to distinguish ten different stages of anatomical age. The lowest of these classes corresponds to that shown by an average boy of about eight years of age (or girl of seven) and the highest to that of an average boy of about fourteen years (or girl of twelve). The range in anatomical age of our ten-year-old group then, including both boys and girls, is about six years.

The accompanying photographs show what radical variations exist in the anatomical development of these children, all ten years old chronologically. The highest class, represented by radiograph No. 1, shows a good development of the pisiform bone, the last of the eight carpals to ossify. It shows, too, a very good development of the ends, or epiphyses, of the radius (the large forearm bone) and of the ulna (the small forearm bone). Ossification of the epiphyses has progressed so far that there begins to be a junction of the epiphyses with the shafts. All the carpal bones of the wrist are well developed, so that there is little space between them. It may be noted, too, that this advanced stage of anatomical development does not necessitate a large hand. The hand shown in radiograph No. 1 is small, but better developed than the larger, Nos. 2 and 3.

Radiograph No. 2 represents the sixth (counting up from the lowest) of the ten classes which we were able to distinguish in ten-year-old children. It is the lowest class in which the pisiform is plainly evident. The pisiform shows simply as a dark spot lying below and to one corner of the *cuneiform*. The epiphyses, particularly that of the ulna, are very poorly developed compared with their condition in class ten (radiograph No. 1).

Radiograph No. 3 represents one of the least developed hands in the entire group of one hundred. There is absolutely no trace of a pisiform bone, and, what is much more striking, scarcely more than a speck to represent the epiphysis of the ulna. According to Pryor, the ulnar epiphysis appears typically at the age of six and a quarter in girls, and seven and a quarter in boys. This hand does not correspond to an age much above these. It will be noted, too, that some of the other bones are very poorly developed, so that there are large spaces left between them.

Sex Differences.—It is well known that girls reach the age of puberty on the average about two and a half years earlier than boys. At this period the anatomical age


p
u.e
r.e
p.
u.c.
r.e.
u.e
r.e.

No. 1 No. 2 No. 3

FIG. 7.—Radiographs showing the variation in anatomical age of ten-year-old children: *p.*, pisiform bone; *u.e.*, ulnar epiphysis; *r.e.*, radial epiphysis

of the girl is clearly well beyond that of the boy of the same chronological age. It is not so commonly realized that this difference between the sexes in anatomical age is well marked by the end of the first year of life, and that it is present in ever increasing degree from the first year up to and beyond the age of puberty. That, however, is the conclusion to which leads either of the measures, eruption of teeth or the ossification of carpals.

A comparison of the sexes as regards anatomical age has been worked out in some detail by Pryor on the basis of carpal ossification. In round figures he finds the following differences: From the age of one to the age of two, the difference in anatomical age is about one-half year. Anatomically, the girl of one and a half years is as old as the boy of two. This difference gradually increases. At the age of four the girl is anatomically as old as the boy of five. By the age of seven and a half the girl is as old anatomically as the boy of nine, and by the age of ten and a quarter she is as old as the boy of twelve and three-quarters. This latter difference agrees with that displayed at puberty, with respect to which we may say that the girl of twelve and a half is as old as the boy of fifteen.

These differences may be summed up in a little table, showing at what ages the two sexes are equal in anatomical age.

The table shows that sex differences, like individual differences, increase with age. A similar table based on dentition would corroborate this fact. American girls at the age of eleven possess on the average 21.3 permanent teeth; the boys can boast only 17.3.[10]

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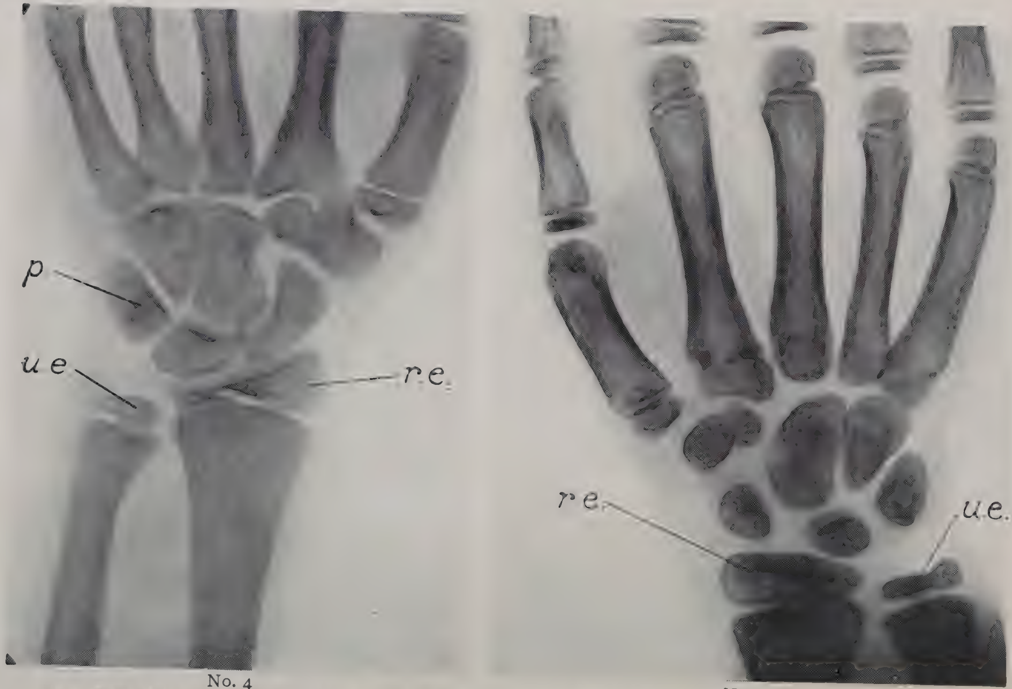
[10] Bean, *op. cit.*, p. 599.

SEX DIFFERENCES IN ANATOMICAL AGE AS MEASURED BY OSSIFICATION OF THE WRIST BONES

Girl's age	Anatomically equivalent boy's age	Difference
1 yr. 6 mos.	2 yrs. 0 mos.	6 mos.
2 yrs. 6 mos.	3 yrs. 3 mos.	9 mos.
3 yrs. 6 mos.	4 yrs. 3 mos.	9 mos.
4 yrs. 9 mos.	5 yrs. 9 mos.	12 mos.
6 yrs. 3 mos.	7 yrs. 3 mos.	12 mos.
7 yrs. 6 mos.	9 yrs. 0 mos.	18 mos.
8 yrs. 6 mos.	10 yrs. 0 mos.	18 mos.
10 yrs. 3 mos.	12 yrs. 9 mos.	30 mos.
12 yrs. 6 mos.	15 yrs. 0 mos.	30 mos.

To illustrate the difference in anatomical age between the sexes, I have chosen two Röntgen photographs. One of these shows the carpal development of the median girl and the other of the median boy, both of the same chronological age group, a group distributed closely around ten and a half. The difference between these two röntgenographs, here reproduced, equals about two years of chronological age. The pisiform bone in the girl's hand (No. 4) is of considerable size, though it does not stand out clearly in the photograph because it is behind the cuneiform bone. It will be noted, too, that the general bone development is much better in the girl's wrist. In particular, the epiphysis of the ulna is thicker, and more closely approaches union with the shaft. In the boy's wrist (No. 5) there is only a vague suggestion of the presence of the pisiform (an indistinct, dark spot at one corner of the cuneiform) and the development of the other carpal bones is much less advanced than in the girl's wrist.

Anatomical Age and Mental Ability.—Children of the same chronological age, as we have seen, differ conspicuously in both anatomical and mental age. This fact



No. 4

No. 5

FIG. 8.—Sex differences in anatomical age of ten-year-old children. Radiograph No. 4 represents the median girl and No. 5 the median boy

suggests that a considerable part of the differences in mental age may be due to differences in anatomical age. Thus the differences in mental age may not always signify differences in brightness, but may be due simply to differences in rapidity of growth—to a difference in the mental and physical stage already reached rather than a difference in the final level to be attained.

Anatomical age gives in physical terms alone the stage of a child's development. The question is, Does his mental stage correspond to his physical? Before we attempt to answer this question, it is important carefully to distinguish between mental *age* and mental *stage*.

Children reach different final levels of intelligence, and at different rates. We may consider mental growth evidenced by children of different degrees of brightness as following different pathways, some of which lead to much higher final levels than others. Now whatever the final level to which a pathway leads, progress along it may be either rapid or slow. Consequently, knowledge of the path the child is taking is a different thing from knowledge of the proportion of its total length which he has covered. Any measure which indicates whether or not the child is following a high path or a low path is a measure of brightness; whereas any measure of the proportion of the path already covered at a given time is a measure of mental stage.

Mental age reports the amount of a child's intelligence, but not the proportion of his final intelligence attained. It is true that from mental age we may try to determine this proportion by use of the intelligence quotient. But when we do this, we assume that all children of the same chronological age have completed the same proportion of their mental development. We say, for example, that whatever a child's mental age at ten, it is ten-fourteenths of what it will be at fourteen. That this assumption, true for the average, is erroneous in individual cases, is demonstrated by the great variation in developmental stage of children of the same chronological age. We must seek a more reliable indicator of developmental progress than mere chronological age. Now anatomical age furnishes us with a good index of the stage of *physical* development. Can we not stretch its use to make it serve as an indicator of the stage of *mental* development?

The surest way to solve this problem of correspondence between mental stage and physical stage is to follow out both the mental and physical development of each one of a large group of children from an early age to maturity. Such an investigation requires a number of years and has not yet been made. In the meantime, light is shed on the question by ascertaining whether there is any considerable correlation between mental age and anatomical age in children of the same chronological age. Such a correlation would indicate that mental development tends to keep pace with the anatomical, and consequently that anatomical age may be used as an indicator of mental stage. As I shall show, there exists a very decided correlation. It cannot be explained simply on the assumption that a high degree of brightness is accompanied by an advanced anatomical age; for there exists no evidence that superior children complete their anatomical development earlier than the dull ones. Its explanation lies solely in the association of *rapidity* of anatomical development with *rapidity* of mental development.

I shall first cite data on the relation of mental age to the degree of development shown by the bones of the wrist. In the case of ten-year-old children, Mr. Severson and I were able to distinguish ten anatomical classes. To indicate the correlation of anatomical stage with mental age, we made a table showing the average mental age of each of the ten anatomical classes. The lowest anatomical class (figure No. 7, radiograph No. 3) had an average mental age of exactly nine years. The highest class (figure No. 7, radiograph No. 1) had an average mental age of over ten years and eleven months. Variation in anatomical age, in children of the same chronological age, thus produced a variation of about two years in mental age.

Our observations are in harmony with those made by Rotch and others. Rotch cites an instance of three boys of the third grade. Their chronological ages were seven, eight and nine respectively. Thus, in mental ability, so far as could be judged from their school work, they were about equal, whereas in chronological age they differed considerably. The Röntgen pictures showed them all to be equally old anatomically, indicating that it is the anatomical age, rather than the chronological, which corresponds with mental ability.

That mental age is related to anatomical is shown not only by its relation to skeletal development but by its relation to the development of the teeth—as discovered by Bean, in a study of the children in the public schools of Ann Arbor, Michigan. Bean called that grade in which were found the majority of children of any given age the modal grade for that age. He then classified the children of all ages from seven to fourteen inclusive into three groups: those who were *in* the modal grade, those who were *above* it, and those who were *below* it. He sums up his findings in the statement that children in the modal grade have an average of eight-tenths of a tooth less than those who are above the modal grade, but nine-tenths of a tooth more than those who are below the modal grade.[11]

The relation of anatomical age to mental age is seen also in the relationship of pubescence to scholarship, on which very decisive data have been gathered by Crampton.[12] He shows that boys of the same chronological age group differ with respect to pubescence according to the high school term which they have reached. For example, among boys between the chronological ages of fourteen and fourteen and a half, the percentage of pre-pubescents in the more advanced terms is much less than that in the first term. The relation between scholarship and pubescence in these boys is shown in the following table, which is typical of the results obtained with other age groups:

RELATION OF PUBESCENCE TO SCHOLARSHIP IN BOYS AVERAGING 14.25 YEARS IN CHRONOLOGICAL AGE

High School Term	Percentage of pre-pubescents
First	42.9
Second	37.3
Third	30.4
Fourth and Fifth	16.7

Crampton also compared post-pubescents with pre-pubescents of each age with respect to the percentage gaining promotion or failure at the end of the term. For each age group he found that the percentage gaining promotion was from seven to ten per cent. greater for the post-pubescents than for the pre-pubescents.

The preceding studies show that in whatever manner we measure anatomical age, we find it correlated with mental ability. We must conclude, therefore, that the development of the brain and of intelligence advances or lags with acceleration or retardation of general bodily development. Whether the brightness of a child is high or low, the rapidity with which he completes his mental growth is correlated with the rapidity of his anatomical development.

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[11] *Op. cit.*, p. 613.

[12] "Physiological Age," Section II. *American Physical Education Review,* vol. xiii, 1908, pp. 224–227.

Relation of Height and Weight to Anatomical Age and to Mental Ability.—All investigators have found that height and weight are much more closely related to anatomical age than to chronological age. This is but natural. The more advanced a child's physical development, the taller and heavier will he be. Thus, Crampton found that children of the same age with a full set of permanent canines averaged from five to seventeen pounds more in weight and from one-half an inch to three inches more in height than those with none.[13] He found, similarly, that post-pubescents average twenty-four to thirty-three per cent. heavier than pre-pubescents of the same age.[14]

We have already seen that mental ability varies with anatomical age. It is reasonable, therefore, to expect some correlation between mental ability and height and weight. Such correlation is now well confirmed. Porter found that the average weight of eleven-year-old boys in the sixth grade was ten pounds greater than the average of those of the same age in the first grade. Similar results were obtained in the case of the other age groups.[15]

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[13] "The Influence of Physiological Age Upon Scholarship." *Psychological Clinic,* vol. i, 1907, p. 120.

[14] *Op. cit.,* p. 116.

[15] "Growth of St. Louis Children." *Transactions of the Academy of Science of St. Louis,* vol. vi, 1894, pp. 263–380.

The average height and weight of the feeble-minded is less than that of normal children, and their divergence from the normal increases with the severity of their mental defectiveness.[16] On the other hand, exceptionally bright children average somewhat above normal children in height and weight. In this connection, it is interesting to note that the children of professional men are taller and heavier than those of the less favored laboring class.[17] I have already called attention to the fact that children of the professional classes are brighter than those of the laboring classes. It is clear, then, that a higher degree of brightness goes hand in hand with a better physical development.

The Educational Value of Measurements of Anatomical Age.—Knowledge of anatomical age has a decided value from the standpoint of education. It is useful in the diagnosis of a child's abilities, physical and mental, in the forecasting of his future development and in planning and regulating his education. It also solves some educational problems that have hitherto been puzzling.

Of first importance is the use that should be made of anatomical age in deciding whether or not a child's mental development is normal. The problem is just how to employ anatomical age in the estimate of a child's true brightness. Brightness, as here used, is measured by the intelligence quotient; that is, by mental age divided by chronological age. The question arises, should we not substitute anatomical age for chronological age in calculating the intelligence quotient? The answer must be negative. The relation between anatomical age and mental age is not close enough to justify substituting anatomical age for chronological. A large difference in anatomical age in children of the same chronological age brings about only a comparatively small difference in mental age. The solution lies in the *correction* of chronological age by the anatomical, not the *substitution* of anatomical for chronological.

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[16] Wylie, "Contribution to the Study of the Growth of the Feeble-Minded in Height and Weight," *Journal of Psycho-Asthenics,* vol. viii, 1903, pp. 1–7; and Goddard, "The Height and Weight of Feeble-Minded Children in American Institutions," *Journal of Mental and Nervous Diseases*, vol. xxxix, 1915, p. 217–235.

[17] See Baldwin, "Physical Growth and School Progress." *U. S. Bureau of Education,* Bulletin No. 10, 1914, pp. 144–150.

It is difficult at present to state exactly what correction should be made. I wish, however, to emphasize that we should not expect the average or normal child's mentality to agree with his anatomical age, if the latter differs widely from his chronological age. All that we should expect, if the child is normal, is that his mental age should deviate *somewhat* from his chronological, in the direction of his anatomical age. If I were to estimate how large this deviation of his mental age from his chronological should be, I would say about one-third as great as the deviation of his anatomical age from his chronological. This ratio is based on the data presented earlier in this chapter, showing that differences of anatomical age amounting to as much as six years in a group of one hundred children, entailed differences in mental age of only two years.

If, then, by inspection of his teeth or by a radiograph of his wrist bones, we find that a child's anatomical age is above his chronological, we should consider the child to be *somewhat* older chronologically than he really is; whereas, if he is retarded in anatomical age, we should consider him somewhat younger than he really is.

That a knowledge of anatomical age is also of great value in preventing mental and physical overstrain, has been pointed out by a number of authorities. According to Rotch, a very large proportion of the nervous and physical troubles of children are due to overstrain caused by forced conforming with general surroundings and school work not adapted to their needs. It is probably conservative to say that when a child's anatomical age is less than his chronological, attention should be devoted primarily to his health. Such a child, no matter how precocious he may be, should not be urged on in his school work, but given plenty of systematic exercise and rest, a thorough medical examination, and, if needed, medical treatment.

To illustrate more in detail the application of a knowledge of anatomical age, Terman may be quoted: "Let us imagine," he writes, "two girls in a fourth grade class who are a little slow in their work and about the advisability of whose year-end promotion the teacher is in some doubt. Both pupils, let us say, are not so low in their marks but that they might be expected, with considerable extra effort, to carry the work of the following grade if promoted. But would it be wise to have the child risk the extra effort this would require? We cannot answer this question on the basis of weight, height, strength of grip, or the presence or absence of external physical defectiveness. But if radiographs should reveal that one of the girls is a year ahead of her age in the physiological development and that the other is a year in retard, there would then be little doubt about the wisdom of risking promotion in the former case and denying it in the latter. A few years hence," he concludes, "may see the installation of the Röntgen apparatus in the hygiene departments of all cities where school medical supervision is practiced." [18]

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[18] "The Hygiene of the School Child," 1914, pp. 68–69.

Besides enabling us better to appraise a child's capacities, anatomical age, as I have stated, offers an explanation of some puzzling educational problems. One of the most baffling of these, a perennial source of discussion, is the fact that girls do better in school than boys. Why do girls obtain better marks, fail less often and show a smaller percentage of elimination from school than boys? I am convinced that these evidences of mental superiority are more than accounted for by the superior anatomical age of the girls. We constantly compare girls with boys who anatomically are a year or two younger. It is unnecessary and altogether groundless to assume, as is so often done, that the schools are better adapted to a girl's type of mind than to a boy's, or that the preponderance of women teachers in our schools gives the girls an advantage over their classmates of the opposite sex. It *is* necessary, however, to concede that girls are more intelligent than boys, because an advantage in anatomical age could not account for superior scholarship unless it carried with it an advantage in mental ability. Now, is it conceivable that girls are more intelligent than boys? However reluctant the confident male may be to make this admission, the facts demand it. As I have pointed out in a previous chapter, the best data at hand show that throughout the grades girls have a slightly higher mental age than boys of the same chronological age.

This surprising proof, that girls are more intelligent than boys should not be misunderstood. Girls are more intelligent than boys only when the comparison is based, as it usually is, on chronological age. But allowance must be made for the greater anatomical age of the girls. To be actually the mental equal of the boys, the girls should exceed them in mental age by *at least one-third as much* *as they do in anatomical age!* Now, the average girl of ten is about twenty-four months ahead of the average boy in anatomical age. One-third of twenty-four months is eight months. To be the boy's mental equal, then, the ten-year-old girl should show a mental advance of eight months over the boy. Certainly, she is not this far ahead of him. She does not exceed him mentally by more than four or five months. Consequently, we may conclude that when proper allowance is made for the girls' superiority in anatomical age, they will be found slightly less intelligent than the boys.

CHAPTER VII

PEDAGOGICAL AGE

Definition of Pedagogical Age on the Basis of "Normal" Ages.—There has long existed an educational tradition that the proper age for entering school is six, and that after entrance progress should be made at the rate of one grade a year. The officers of our schools are in the habit of speaking of the age of six as the "normal" age of a child in the first grade; of seven as the normal age in the second; and so on, allowing one additional year for each additional grade. According to this theory, there is a normal age for each grade. A child who is over the normal age for his grade is called retarded, or below grade, and one who is under the normal age is called advanced, or above grade.

It is the usual thing to allow an extra year in the way of a concession to the child. In this way, a child in the first grade is not retarded unless he is eight years of age or over. To concede this additional year is no more than fair, providing the ages are taken in the month of June or near the close of the year, as they should be. This becomes evident if we consider what is meant by the statement that a child should enter school at the age of six. The age of six may mean anything from six to seven. A child entering at the age of six may, then, be entering actually at the age of six years and eleven months. At the end of the school year, he will be nine months older—seven years and eight months. It would hardly be fair to call this child retarded. If we neglect fractions of a year we cannot call a child in the first grade retarded unless he is eight or over.

Allowing the child an extra year, we obtain the following standard of "normal" ages for each grade:

Grade	Normal ages
1	6 or 7
2	7 or 8
3	8 or 9
4	9 or 10
5	10 or 11
6	11 or 12
7	12 or 13
8	13 or 14

This standard is more widely accepted than any other, and in spite of its lack of precision as compared with the norms that have been established for mental tests, it is a very useful one. It affords the best basis for a definition of pedagogical age. On this basis, we may define the pedagogical age of a child as the "normal age" of the school grade which he has attained. Thus, if a child is in the fourth grade, pedagogically he is nine or ten years of age, since nine and ten are the normal ages for the fourth grade. If the child's chronological age happens also to be either nine or ten, the child is said to be of normal pedagogical age, or in the normal grade for his age; if his chronological age is over ten, he is pedagogically retarded, or below grade; whereas if his chronological age is less than nine, he is pedagogically advanced, or above grade.

It is impossible to be too careful in distinguishing between the terms above grade and below grade, on the one hand, and superior and dull on the other. Recent statistical investigations have shown that the theoretically normal ages are not quite those of the average child. The average child does not measure up to the ideal standard. Consequently, when a child falls below the grade in which he should be according to the theoretical standard, he is not called dull nor mentally retarded. He is simply pedagogically retarded. While many mentally retarded children are below grade, certainly many are below grade who are not mentally retarded. It is probable that the children who are above grade are, for the most part, above normal in brightness; but many children who are above normal in brightness never rank above grade. It is clear, then, that the relation between a child's mental age and his pedagogical age always has to be determined by investigation; it can never be taken for granted.

The Prevalence of Pedagogical Retardation and Advancement.—The pedagogical standing of school children has been the subject of several elaborate investigations. Careful inquiry has been made into the number of children pedagogically normal, retarded or advanced. Very serious conditions have been discovered which raise some of the most deeply rooted problems in psychology and education, problems which we are only beginning to solve.

Ayres, in a now famous investigation, found that, on the average, about one-third of all the pupils in our city public schools belong to the retarded or above age class.[1] The later results of Strayer,[2] based on investigations in 384 cities, agree substantially with those of Ayres, though, to be exact, they show a slightly greater percentage of retardation. The percentage of retardation is, of course, not the same in all schools, but shows great variation.

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[1] Ayres, "Laggards in Our Schools," 1909, p. 3.

[2] Strayer, "Age and Grade Census of Schools and Colleges," *United States Bureau of Education, Bulletin,* 1911, No. 5, p. 103.

Ayres found the percentage as low as 7.5 in Medford, Massachusetts, and as high as 75.8 in the colored schools of Memphis, Tennessee.

To understand the real extent of pedagogical retardation, let us consider what it means to say that one-third of American city school children are retarded. It means that probably a decided majority of all the children entering the schools of the average city will not finish the eighth grade by the age at which they should "normally" finish. A number who become badly retarded simply never finish the eighth grade at all, but drop out; and if to this number are added those who do finish but only after they are over age, we find usually that the total is well over one-half the number of children entering the system. Moreover, many children who are retarded become badly retarded. Of all retarded children in a school system nearly half show two or more years of retardation. By counting up the total of years of retardation, consequently, we obtain a much larger number than the number of children retarded.

Retardation begins in the first grade and increases rapidly. When we give the average of retardation as one-third, this means that one-third of all the children are retarded, including even those in the first grade, who have had little time to become retarded. Now statistics uniformly show that most of the children who once become retarded stay retarded. Moreover, with each additional grade, additional pupils, on account of failure, become retarded. Consequently, the percentage of retarded children in a grade continues to increase from the first grade up to the higher grades. It would keep on increasing clear up to the eighth grade, except for the fact that many retarded children (far more of the retarded than of the others) drop out from one of the last two or three grades. In many schools, not over one-half the total number entering finish the eighth grade. Discouragement, economic pressure at home, and the failure of the truancy laws permit of an extensive process of dropping out or "elimination." This elimination, and the further fact that elimination is most marked among the retarded, accounts for the tendency of retardation percentages to remain constant or to show a shrinkage beyond the fifth or sixth grade. That the percentage of retardation reaches its maximum as early as the fifth or sixth grade does not mean that in the last two or three grades there are no new children added to the ranks of the retarded. New ones are added; but they merely take the place of others who have dropped out.

Contrasted with the great mass of pedagogically retarded children, the number who are pedagogically advanced is discouragingly small. According to statistics from Minnesota schools there are eight retarded children to one who is advanced;[3] and according to the statistics of Strayer[4] this ratio is about the average for the cities of the United States. Thus, by the prevailing school standards, there are eight times as many retarded children as advanced children. A moment's thought shows that this is an extremely serious condition. We have seen in preceding chapters that so far as mental ability is concerned, there are very nearly the same number of children above the average as below it, the same number of superior as of dull. Clearly, then, when we find eight children who are below grade to one who is above, we may be sure that children are not being properly classified in the grades of the public schools.

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[3] F. E. Lurton, "A Study of Retardation in the Schools of Minnesota." *Science,* 1911, p. 786.

[4] *Op. cit.,* p. 103.

The figures would not be so alarming if the superior children, while not advanced in grade, were yet given different or more difficult work, or held up to higher standards. This is not the case. As a rule, if any special provision at all is made for the exceptionally bright children, it is simply some arrangement whereby they can skip a grade or a half-grade.

Our schools are plainly much better adapted to the discovery of dullness than of exceptional brightness. If a child can cover one grade's work in one year, he can keep step with the procession; there is little opportunity to do more; and if he cannot make progress at the standard rate, he must fall behind. The standard is a little too hard for the average, so that the number who fall behind exceeds the number who remain "normal." The system in vogue in the public schools results in a classification of children whereby the majority are retarded by the age of fifteen, and the minority normal. The existence of a large class of children superior to the normal is practically ignored.

Elimination as Studied by Age and Grade Distributions.—The subject of pedagogical retardation is closely related to that of elimination from school. It will be well, therefore, before proceeding to a further analysis of retardation, briefly to review the facts concerning elimination. These facts are best brought out by the study of tables, known as age and grade distributions, which show for an entire school or an entire school system the number of children of each age in each of the grades. A fairly typical sample is the accompanying one, showing the age and grade distribution of all the white children in the regular elementary schools of the city of St. Louis at the end of the school year.[5]

It will be observed that the totals at the right give the number of children of each age in the school system, or, in other words, the age distribution. The totals at the bottom give the number of children in each grade, or the grade distribution. The number of children who are normal in age for their grade is given in numbers between the heavy staircase lines. All those above the upper heavy line are advanced, or under age, and all those below the lower heavy line are retarded, or over age. The total number of advanced children is 2001, or 3.2 per cent., while the total number of retarded is just ten times as great, 20,227, or 32.2 per cent.

Examination of the number of children of each age, reveals that, as in the great majority of American city schools, the number of children of each age is fairly constant from the ages of seven to twelve inclusive. Nearly all the children are in school by the age of seven, and nearly all remain there through the age of twelve. With a stationary population, then, it would be reasonable to expect the age groups seven to twelve to remain roughly the same. The only factor to cause variation would be the population factor. This factor is regulated by two elements, death, and the number of children born in each succeeding year. The population factor tends to bring it about that there are in the community fewer twelve-year-old children than seven-year-old children. This is partly because a larger percentage of children die by the age of twelve than by the age of seven, and because, if the community has been growing, a smaller number of

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[5] Sixty-Second Annual Report of the Board of Education of the City of St. Louis, Missouri, for the year ending June 30, 1916, p. 322.

AGE AND GRADE DISTRIBUTION OF WHITE CHILDREN IN ST. LOUIS PUBLIC SCHOOLS

Age	Grade								Total
	1	2	3	4	5	6	7	8	
5	38								38
6	3953	233	1						4,187
7	4095	3044	264	2					7,405
8	1105	4331	2241	214	8				7,899
9	217	1701	3732	1915	243	11	1		7,820
10	60	431	1752	2753	1171	230	18	1	6,416
11	17	187	952	2502	3086	1368	364	25	8,501
12	7	50	294	959	2062	2331	1425	348	7,476
13	3	18	112	405	1008	1766	2161	1330	6,803
14	1	4	21	105	287	650	1295	1684	4,047
15			7	17	68	170	478	971	1,711
16			3	6	11	29	115	308	472
17				3	1		14	50	68
18							1	4	5
Total....................	9,496	9,999	9,379	8,881	7,945	6,555	5,872	4,721	62,848
Advanced (per cent.).......	0.4	2.3	2.8	2.4	3.2	3.7	6.5	7.9	3.2
Retarded (per cent.)........	14.8	23.9	33.5	45.0	43.3	39.9	32.4	28.2	32.2

children were born in it twelve years ago than seven years ago. Ayres calculates that, on account of these two factors alone, it is reasonable to expect a decrease of over 10 per cent. in the number of children as we pass from seven to fourteen years of age.

In the average city, children begin to drop out of school at the age of thirteen. Usually only a small percentage are eliminated at as early an age as thirteen, but during the ages of fourteen, fifteen and sixteen, elimination is extensive. After the age of sixteen, only a small fraction remain.[6]

Age distributions are often used as a basis upon which to estimate the number of children entering the school system each year. This may be taken as approximately equal to the average of the number at each of those ages, usually seven to twelve, at which the number tends to remain constant. For example, from the St. Louis age and grade distribution we could determine the number of white children entering the system each year for the past few years by taking the average of the age groups seven to twelve inclusive. We would thus find that the number entering each year was about 7600.

Turning now to the distribution of children by grades, it is interesting to note how the size of each grade compares with the number known or supposed to be each year entering the school. As a rule the number of children in each of the first four grades is considerably greater than the number entering. All the children who enter remain at least through these grades, and they pile up in numbers because they are held back by failure to pass. The fifth grade is typically about equal in size to the number entering; the sixth grade usually shows a falling off;

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[6] See Strayer, *op. cit.*, pp. 29–44.

and beyond this, the size of each grade decreases until in the eighth grade there are on the average scarcely more than half the number entering. These figures mean that American city schools on the average tend to carry nearly all their children into the fifth grade, but scarcely more than half of them through the eighth grade. From one-tenth to one-twentieth of the number entering the grades reach the fourth year of the high school. Cities differ widely, however, with respect to their ability to hold children through the higher grades.

The Relation of Elimination to Pedagogical Retardation.—The facts of elimination, which have now been briefly reviewed, need always to be kept in mind in considering statistics on pedagogical retardation. It is elimination alone which keeps the percentage of retardation from mounting up to well over fifty per cent. in the eighth grade. In the St. Louis schools, for which I have given an age and grade distribution, it may be noted that, as early as the fourth grade, the percentage of retarded children has climbed up to 45. At the eighth grade it has come down to 28. Now shall we conclude that in the upper grades, a great many retarded children catch up to grade? Some do, but they are the exceptions. The decrease in the percentage of retardation is due not to catching up, but to elimination. It is easy to show that were it not for elimination, something like 55 per cent. of the children in the eighth grade would be retarded, simply by determining what percentage of the number entering finish the eighth grade at or below the normal ages. The number entering, as already pointed out, may be taken roughly as 7600. The number in the eighth grade at or below the normal ages, as indicated by the age and grade distribution, is 3388, or about 45 per cent. of the number entering.

The remaining 55 per cent. either never reach the eighth grade or else are over age when they do so In the St. Louis schools, then, which show a percentage of retardation of 32.2, certainly well over half of the children fail to complete the eighth grade before the age of fifteen.

In the average American city school, the majority of children are retarded by the time they reach the eighth grade or would be did they stay in school until they reached that grade. In Minnesota a state-wide investigation was conducted several years ago by a joint committee of school superintendents and psychologists. On the basis of age and grade distributions, it was concluded that over seventy per cent. of the children in the schools considered in the committee's report [7] failed to complete the eighth grade by the age of fifteen. It is conservative to say of schools which show a proportion of retardation as great as the average, namely, a proportion of slightly over one-third, that from fifty to seventy per cent. of the children are failing to meet the theoretical expectation that they will finish the eighth grade by the age of fifteen. To attack the problem of pedagogical retardation, therefore, is to attack the problem of the fifty to seventy per cent. who do not fit our present school system.

Causes of Pedagogical Retardation.—Since pedagogical retardation means simply a lack of adjustment between the child and the school, we may regard as responsible for its causation either the child or the school. The causes attributable to the school are more easily changed than those within the child. We shall consider first the less remediable causes, those resident in the child. Of these, those which have been most carefully investigated are sex, health and freedom from physical defects, nationality, regularity of attendance, intelligence and personality.

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[7] Report of the Joint Committee, 1911. The members of the committee were Superintendents S. L. Heeter and F. E. Lurton, Principal A. G. Gilette, and Herbert Woodrow.

As far as sex is concerned, it has been found that girls make more regular progress through the grades than boys. The boys show a larger percentage of repeaters and a larger percentage of retardation than the girls, while a smaller proportion of boys than girls remain in school to the eighth grade.[8] These facts establish the conclusion that the school achievements of girls are better than those of boys. I referred to this matter in the discussion of anatomical age. In that connection an explanation was offered. It is simply that the girls develop at a more rapid rate, so that as a rule they are anatomically older than the boys of the same chronological age. And their greater success in school is fundamentally due to the fact that their mental development tends to keep pace with their anatomical development. No doubt other factors come in, particularly in the reasons why girls show a smaller percentage of elimination than boys. The girls are not subjected to the same economic pressure to leave school in order to take a money-earning job.

The relation of physical defects to intelligence and, incidentally, to success in school, has been discussed in a previous chapter. All investigations agree that such defects are important in helping to produce failure in school work. In general, those children who fail most frequently show the largest number of physical defects, and their defects are usually more severe. The child without physical defects has a slightly greater chance than the one with them, of passing through the grades without a failure. In certain cases physical defects may be the chief cause of pedagogical retardation. This is the case, for example, when a child with very bad vision is not provided with glasses. On the other hand, regarding retardation in general, physical defects are far from being the chief factor. This is shown clearly enough by the slight difference between retarded children and normal and advanced children in the percentage having physical defects.

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[8] Ayres, *op. cit.*, p. 157.

The nationality factor entails considerable divergence of results. Certainly in some localities children of one nationality may do better than those of another. Ayres concludes from his study of children of different nationalities in the New York City schools, that children of different nationalities differ radically as to ability in school work. In Minneapolis, where there are a large number of children of Swedish and Norwegian parentage, as well as a fair sprinkling of Bohemian, English, French, Irish, Polish and German, nationality appears to be an almost negligible factor. A tabulation of the ages and grades of two thousand children representing all these nationalities as well as those who gave their parentage as American, showed no reliable difference as regards nationality.[9] There is even disagreement concerning the importance in school success of ability to use the English language. Ayres writes that, " Wherever studies have been made of the progress of children through the grades, it has been found that ignorance of the English language does not constitute a serious handicap." [10] In support of this conclusion, he cites the experience of the department of education of Porto Rico in changing its schools from the Spanish to the English basis. The change, it is alleged, was effected with little or no loss of time on the part of the pupils. Ayres' position on this point seems to accord with the findings of the majority of investigators, though not with all of them. On the whole, the evidence found in the schools indicates a speedy assimilation of the foreign element, so that, although here and there nationality and ignorance of English may be a cause of failure in school, it is one which in most localities is not very serious, and which in the long run will eliminate itself.

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[9] These data were gathered in the course of a study of the mental associations of children. A list of the nationalities represented will be found in " Children's Association Frequency Tables," by Woodrow and Lowell. *Psychological Monographs,* No. 97, 1916, pp. 31–32.

[10] *Op. cit.,* p. 116.

The importance of regular attendance is emphasized by all students of pedagogical retardation. It is obvious that failure to attend school means failure to benefit by the instruction given therein. We do not need statistics to prove that absence from school is an important cause of failure and pedagogical retardation; but it is surprising what an enormous amount of absence from school the statistics prove to exist. An examination of school reports led Ayres to conclude that less than three-fourths of the children in our cities continue in attendance as much as three-fourths of the school year. Examination of school records shows that there is a certain maximum number of days of absence, which if exceeded, nearly always results in failure. In the Minneapolis schools, absence of ten to twenty days in a half-year, or even twenty to thirty days, may not result in failure, but absence totalling more than this is almost sure to do so. Now absence of more than thirty days in a half year is quite frequent, and since it almost certainly means failure, it is clear that a considerable proportion of pedagogical retardation, perhaps as much as fifteen per cent., can be attributed solely to irregular attendance. Of course a much larger percentage is due to it in some part.

Turning now to the factor of the child's intelligence and character, we find ourselves facing unquestionably the main causes of failure in school, in so far as these causes lie within the child. Whether intelligence, as such, or certain traits of character more or less separable from intelligence are the more important, it is hard to say; but probably intelligence is the fundamental factor. So true is it that pedagogical standing is dependent upon intelligence, that a high correlation between the two is often set up as one of the main tests of the soundness of any method for the measurement of intelligence.[11] Grade standing and intelligence standing by no means run parallel, partly because of faulty classification of children in the grades, and partly because a number of factors other than intelligence have a great deal to do with pedagogical standing; but there is no single factor that has been shown to have anything like as high a correlation with pedagogical age as has mental age.

It is clear that for each grade there is a certain minimal mental age, which the pupil must reach if he is to have a very good chance of success. For example, a child of mental age nine has not much chance of passing the fifth grade, at least without repeating it. As a reasonable minimum he should have a mental age of ten; and to have a really good chance of passing he should have a mental age of eleven. In general, to have a reasonable chance of success in the grade which is normal for his age, a child should not be much retarded mentally. His mental age should not be much below his chronological.

A considerable percentage of children have a mental age less than their chronological, and so are in danger of becoming pedagogically retarded. At first, their mental age may not be low enough to fall below the requirements of the grade normal for their age. But, as we have seen, the retardation of a mentally retarded child, when measured in terms of months or years, increases as the child grows older. Consequently, as children grow older a constantly increasing number must come to have a mental age too low for successful work in the grade which corresponds to their chronological age; and so a constantly increasing number will become pedagogically retarded. Children who have once failed in a grade because their mental age has fallen below the requirements, although they may still grow mentally and so in the course of years make another grade or two, will tend to fall farther and farther behind. Their mental quotient tends to remain constant, but their mental retardation, measured in years, tends to increase with age. Consequently their pedagogical retardation tends to increase until at last they drop out of school.

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[11] See Chapter II, pp. 33 and 34.

Concerning the influence of character or personality, there exist very few accurate data. On general principles there is every reason to suppose that success in school, like success in life, depends largely on conscientious and persistent application, upon industry and the ability for hard work, on the interest and enthusiasm brought to bear on the work, and even upon personal manners and appearance and ease of speech and action in the presence of others. Many of these traits no doubt affect the results of our measurements of intelligence, and to such extent as they do so, form a part of intelligence. On the other hand, they depend considerably upon the individual's emotional nature. For example, a child may take a dislike to one teacher and be friendly to another. Such factors escape any methods so far devised for their measurement. For the present, we must rest content with the knowledge that there are a great many emotional characteristics and traits of character which are certainly vastly important, and to which the teacher and all those interested in the child's success must give the greatest consideration.

Remedial Measures.—Having considered some of the main causes of retardation in so far as they consist in traits of child nature, we should, logically, proceed to point out the causes lying within the school. To recognize a cause of retardation in the school, however, means to recognize something which should be changed. It is by changes in the school that the problem of pedagogical retardation must be solved. Child nature can be changed but little; and even this little has to be accomplished mainly by changes in education, and so by changes in the school. Consequently, instead of an abstract discussion of causes of pedagogical retardation in the school, I shall endeavor to make my criticism constructive by considering the more practical question of the changes that should be made in the school in order to meet the situation. Obviously there is no need for changing anything which is not to some extent a cause of the present unsatisfactory conditions.

The problem of decreasing retardation in the schools is merely a part of the more general one of adapting education to the capacities of children. It is a mistake to adopt, for the benefit of the child who fails, any measures that interfere with the amount of attention given to the brighter child, or to make special provision for the failing child without at the same time making special provision for the exceptionally bright child. To all children, bright or dull, the community is under the same obligation—that of determining the capacities of each one and developing them to the point of greatest possible serviceableness.

Some persons, perhaps, imbued with the importance of paying more attention to the superior children might ask, "Why bother at all about failure? Why not simply have the child who fails take the work of the grade over and over until he passes it? After all, is this child not receiving as high an education as his intelligence and zeal will permit?" It is true that, in many cases, the child is receiving about all the education he can digest of the sort offered. The point to be kept in mind, however, is that *the failing child is not receiving the right kind of education.* The real question is whether these children who fail should not be offered work different in kind and taught by different methods, in which they would not fail —in short, work to which they are better adapted.

A child's failure to pass is merely a failure on the part of the educational procedure used to produce the expected result. Each failure constitutes a demand for education along new lines. Education must avoid doing the spiritual injury of branding the child a failure. Instead, it must cultivate the spirit of initiative and self-reliance, and the satisfaction and desire for further achievement which result from progress and the taste of success. The education that breeds these qualities will be the one which develops those capacities that the child *does* possess, which finds some work in which the child will *not* fail and which, by training in this work, guides the child into a life of maximal usefulness.

The problem of changing the existing system in any city so as better to meet the needs of the children is always an exceedingly complex one, even aside from questions of expense. It is hard to name any one change that of itself will produce much improvement. A change in any one respect usually calls for other changes, upon which it depends for its success or failure.

Of all the measures that could be suggested, none lies so close at hand as a simplification of the curriculum. By simplification is meant a reduction in the amount of work that all the children, exclusive of the feeble-minded, are expected to take in common. Simplification is accomplished by a stricter interpretation of what are the essentials, and a strict limitation of the common program to these essentials.

Does simplification mean lowering of standards? If it does, it will do no good; for while it may produce less failure, it will bring about more holding back of the bright pupils. A radically simplified curriculum should not, however, result in a lowering of standards. Its very meagreness should serve to emphasize the fact that additional work is essential. It allows more time to be devoted to this additional work, and more adaptation of this work to the individual needs of the pupils. The simpler the program for all pupils in common, the easier it is to make clear the necessity and to provide the time and facilities for additional individual work. The individual work for the intellectually less able pupils should be in the line of practical occupations, such as manual training, sewing and gardening; for the more able it should consist of more intensive work along the same lines as the common program, as well as of additional academic subjects and additional practical or occupational subjects. Properly interpreting its advocates, then, simplification does not mean less work for anybody. Primarily it means simply different work for the less able and the more able children of each grade with a consequent reduction in the amount of work in common.

Changes in the direction of simplification should be accompanied by a more just and accurate system of grading pupils. Great progress has been made in recent years by doing away with the old lock-step system and installing a system of rates of progress which vary to suit the pupils Formerly, in a vast majority of our towns and cities, a child who failed in one or two subjects had to repeat the entire year's work. Nowadays, it is common to divide the years' work into at least two semesters. Many recommend the further step of grading and promoting the children separately in each subject, after the manner of high schools, colleges and universities. Educational measurements have shown that even under the present grade system the average child is often so much more capable in some subjects than in others, that he really belongs in different grades in different subjects. For example, a fifth grade child, when tested by the modern measuring scales,[12] may be found below the fourth grade average in handwriting, and at the same time above the sixth grade average in composition. Why, then, should such a child not be taking writing with fourth-grade pupils and composition with sixth grade pupils? It is already customary to provide special teachers and special classes in drawing, singing, writing, cooking, sewing and manual training. Progress appears to lie in the direction of further organization of instruction by subjects, particularly in the upper grades.

Coupled with the tendency towards greater accuracy in grading, is the tendency towards the multiplication of special classes and parallel courses. There has been a striking increase in the number of auxiliary classes for feeble-minded children. There has also been a movement for the provision, in the upper grades, of special classes for exceptionally bright children, and also for the provision of classes for pedagogically retarded children, usually children who are dull or backward. Further, the need for parallel courses is more and more being recognized. In some cases, these parallel courses are simply devices which permit different pupils to cover the same work in different periods of time. For example, the work of the last five grades may be divided into two halves, and the grades arranged so that each half may be taken by the brighter children in two years, and by the slower ones in three years. More commonly, however, the parallel courses differ in character. One course usually sticks close to the traditional program, whereas the other is mainly industrial and vocational in nature and appeals chiefly to those who are to enter commercial or industrial work upon reaching the age limit of compulsory attendance. These industrial and commercial courses, it is claimed, are very valuable in preventing the early elimination of retarded children. In farming districts, courses in preparation for agricultural life are also of great value, and often fit children with whom the traditional curriculum fails.

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[12] For description of these scales, see Starch, "Educational Measurements," 1916; Monroe and others, "Educational Tests and Measurements," 1917; and Chapman and Rush, "The Scientific Measurement of Classroom Products," 1917.

So far we have discussed mainly changes in curriculum and school organization as being necessary to cope with the evils of pedagogical retardation. There are other administrative measures, however, that are important and that aim directly at two of the causes of failure which have been attributed to the child rather than the school. One of these causes is bad physical condition; the other, poor attendance.

Irregular attendance, experience shows, can be successfully combated. The main things necessary are an accurate, annual, school census, that is, a census of all children in the community who are of school age, and an efficient enforcing of the truant laws by the truant officers. That there has been marked improvement in school attendance in recent years is indicated by the great reduction in illiteracy. In 1900, of all children in the United States from 10 to 14 years of age, there were 42 in every 1000 who could neither read nor write. In 1910, there were only 22 per 1000. In all probability the federal census of 1920 will show a still further reduction in the percentage of illiterates.

To the physical condition of children, there is no doubt that there should be paid even greater attention than at present. In many rural communities conditions are little short of scandalous. The whole movement towards specialized forms of training to meet the special needs of pupils must be accompanied by a greater concern in this matter. It must lead to more care for the heating, ventilating and cleanliness of school buildings; also to systematic courses in physical culture and drill as well as to supervised play; and to the universal adoption of a system of medical inspection by which the physical ailments and abnormalities, that hinder health and happiness as well as school progress, shall not only be detected and reported, but corrected.

It should be noted, however, that better physical care, like better methods of teaching, will help the children who are above grade as well as those who are below grade, since the latter are only slightly more defective physically than the former. This, of course, is a greater reason for doing all that is possible; but it follows that the problem of meeting the needs of children of different degrees of ability will by no means be solved simply by better attention to the physical side. If it enables a larger number of pupils to keep up to grade it will at the same time increase the number who should be above grade, and therefore make the problem of proper provision for the abler children more acute. If better health will enable a dull child to succeed with the present curriculum, it will enable a superior child to do more than to succeed with that same curriculum; and to hold the superior child down to a course that is too easy for him is as great a mistake as to give a dull child a course of study that fails because it is too hard. The same considerations apply here as to improved methods of teaching. If better teaching can enable a pedagogically retarded child to come up to grade, what can it not do for the normal or pedagogically advanced child?

Whenever a child's actual attainments are normal or above normal, and yet lag behind his possible attainments, there exists what we may term invisible retardation. Better care of health and better teaching technique, both of which are imperative, may help to reduce the amount of pedagogical retardation, but they will not go far in solving the general problem of adaptation of education to the needs of the child, simply because to very nearly the same extent that they alleviate pedagogical retardation they aggravate what we have called invisible retardation. And invisible retardation of an able child is fully as serious as the more apparent retardation of the child who is below grade.

The preceding discussion should make it clear that the problems arising from the facts of pedagogical age are problems of school administration. Failure should be thought of not as failure on the part of the child, but as failure of school authorities to provide the proper education. Pedagogical retardation, visible or invisible, means faulty administration. The problem is not the bringing of retarded children "up to grade." It is much broader and deeper than that. It is providing for each child that education which is best suited to him. This plainly requires first of all a diagnosis of the child's abilities. The efficiency of the school system depends on the degree to which the educational results agree with the diagnosis of mental ability. With a child of little mental ability, successful education means training for very humble occupations. With a child of exceptional mental ability, successful education means, not getting the child through eight grades in eight years or even in six years, but preparing him to be a leader in society.

CHAPTER VIII

SIMPLE MENTAL PROCESSES

Intelligent Behavior and Mind.—Intelligence shows itself only in behavior; behavior is everything that an individual does. It includes all the activities of a child as he takes the Binet intelligence tests. It includes going to school, reading and writing, crying and laughing, and answering questions in geography and solving problems in arithmetic. Later in life it includes earning a living, by the conduct of a business, by teaching, or by the performance of some other service; it includes getting married, keeping house, rearing children and providing for their future; it may mean fighting and the conduct of war, the research that leads to new inventions, and acts of charity and of worship. Behavior is the sum total of life's activities; and it is by these activities that intelligence must be judged.

As to the type of behavior which may be labelled intelligent, I believe it is impossible to be more definite than to say that intelligent behavior is successful behavior. "The essential characteristic of all intelligent action," writes Kirkpatrick, "is, from the objective point of view, that it shall be adapted to the securing of useful ends."[1] Useful or successful behavior is behavior which benefits the individual and the society to which he belongs. It may be objected that there are many widely different conceptions of what is good, and consequently many different standards of success. But to just the extent to which this is true, there must be different types and standards of intelligence. However, for certain practical purposes it is possible within limits to agree upon what is to be regarded as success, particularly in the case of children. This is the less difficult, as intelligence means not the capacity for success along any one line of endeavor, but general capacity, the capacity which determines whether one individual would, on the average, do better than another in any and all performances in which he might conceivably be tested. Thus, a man might be eminently successful as a billiard player, or even as a musician, and yet not be above average in intelligence. Success in these special lines indicates special talents; but whether their possessor is to be rated as above average in intelligence depends upon whether he could succeed in the majority of all desirable lines of performance better than the ordinary individual.

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[1] "Genetic Psychology," 1908, p. 178.

Now, while the evidence of intelligence must consist always in behavior, the kind of behavior which is regarded as intelligent cannot occur except by the aid of mind. Highly intelligent conduct requires thought and attention, discrimination, judgment and reason. It is as impossible to be highly intelligent without a good mind as to have a good mind and remain unintelligent. Indeed, one may go so far as to say that successful performances should not be regarded as acts of intelligence unless their success is due to mental processes. When it is the result of luck, or physical strength, or good health, success is not a sign of intelligence. To be accepted as proof of the latter, it must show some signs of mental action, that is, some signs of learning, of profit from experience, and of wisdom. Intelligence, then, is the capacity for success in life in so far as success is gained by the use of mind.

Since intelligence means the capacity for success in those tasks which require mental activity for their execution, our next question is concerned with the nature of this mental activity. Is it possible to find some one mental process, some characteristic mental activity, upon which success depends? A number of psychologists have sought such a fundamental process, but the diversity of their findings indicates that no one aspect of mind can be singled out as the essence of intelligence.

Nearly every important phase of mental activity has been identified with intelligence. Thus, for Ebbinghaus, the main constituent of intellectual ability is the combining activity of the mind—that is, the power to unify into meaningful wholes the haphazard and independent items of experience. For many, including Wundt,[2] one of the most famous of all psychologists, the process most indispensable to the manifestation of intelligence is attention. It is on the basis of this power of attention, or concentration, that Sollier defines the various grades of feeblemindedness.[3] With Binet, intelligence is largely a matter of sound judgment. At the same time, he links it closely with the power of voluntary attention, by which he means the power to apply intensely one's mental faculties to the new situations with which he is constantly confronted.[4] Stern defines intelligence as the capacity of an individual "to adjust his thinking to new requirements."[5] The processes of judgment and of thought emphasized by Binet and Stern are merely aspects of reasoning ability. This ability more than any other, perhaps, is accredited with first importance. According to Tredgold, it is defective reasoning that constitutes the chief characteristic of feeble-mindedness. Another capacity frequently emphasized, which does not differ much from attention, is the capacity for persistent effort, the capacity for steadfastly pursuing a fixed purpose.

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[2] "Elemente der Physiologischen Psychologie," 6th ed., 1908, vol. i, pp. 378–386.

[3] "Psychologie de l'idiot et de l'imbécile," pp. 36–37 and 60–74. See also Consoni, "La mesure de l'attention chez les enfants faibles d'esprit." *Archives de psychologie,* vol. ii, 1903, p. 250.

[4] "Attention et adaptation." L'année psychologique, vol. vi, 1899, pp. 393–395.

[5] "The Psychological Methods of Testing Intelligence." Trans. by G. M. Whipple, 1913, p. 3.

Plainly it is impossible to find any one mental process that can be identified with intelligence. It is true, that certain mental functions, such as attention and reasoning, are more closely related to intelligence than others. It must be remembered, however, that the mind, like the body, functions to a large extent as a single organism, and that the more important mental processes involve all the others. For example, in the case of reasoning, it is clear that one's ability depends upon his knowledge; his knowledge in turn is dependent upon his perceptions and his memory, and also upon his power of attention and his interests. Again, in the case of sensory discrimination, it is impossible to distinguish between acuteness of the senses and keenness of attention. We cannot test visual acuity, for example, without testing attention; for a person totally inattentive to visual impressions would to all intents and purposes be just as blind as one whose lenses were opaque. It is thus very difficult to state with precision the relative importance of the various mental processes. All mental processes influence behavior, although they do not have equal weight. Their part in intelligence is proportionate to their importance in securing a successful adjustment to the problems of life.

It is important to study the contribution of even the simpler mental processes towards intelligent behavior. To these processes the remainder of this chapter is devoted. In the following one, two very fundamental processes, association and attention, are to be considered; the next takes up some of the more complex mental operations. The simpler mental capacities are: Sensory capacity, that is, the capacity for receiving sensations and discriminating between them; perception, or the observation of external objects; the capacity for imagery; and the capacity for feelings of pleasantness and unpleasantness.

Methods of Measuring Sensory Capacity and Estimating Its Relation to Intelligence.—In estimating an individual's sensory capacity, it is customary to use measurements of the smallest discoverable difference between two stimuli acting on the same sense organ. Thus, one test is given to determine the smallest perceptible difference in the loudness of two sounds; another, to ascertain the smallest perceptible difference in their pitch. In the case of vision, the smallest noticeable difference in brightness between two grays may be determined, or in the tone, or hue, of two colors. The accuracy of spatial discrimination is also studied, as in the visual acuity test, already described, or in tests of ability to discriminate length. To measure the fineness of the sense of touch, it is common to use the smallest distance which may separate two compass points applied to the skin and yet permit of their being recognized as two. This distance is known as the threshold for the discrimination of two points. Another test is the measurement of the smallest noticeable difference between two weights, and still another is the amount of pressure required on the skin to produce a sensation of pain. All of these sensory tests have been used in the study of the relation of sensory discrimination to intelligence, a relation which, because of its bearing upon sense training as well as many other problems, has been the object of a long series of experimental investigations and of much discussion.

In such investigations, intelligence has usually been graded by taking the average score in a large number of mental tests, or by the average of school marks, or by estimates of intelligence on the part of teachers or others, or by several of these methods combined. The procedures employed in the measurement of the fineness of sensory discrimination have varied greatly, but on the whole, they have been fairly accurate.[6]

In order to measure the closeness of relationship between the capacity of sensory discrimination and intelligence, it is necessary to obtain measures of each, for a large number of individuals, preferably of the same age and sex. These measures are arranged in two columns, each number in a column representing the sensory capacity of one individual, and a corresponding number in the other column, his intelligence. To ascertain the relationship between sensory capacity and intelligence, then, it is necessary merely to determine the extent to which the numbers of one column rise or fall in harmony with those corresponding in the other column. This is accomplished by means of a mathematical formula, which works out in such a way that if the numbers of one column run perfectly parallel with those of the other, a correlation of one hundred per cent. is obtained, whereas if there is no relationship between the two columns of numbers a correlation of zero will be obtained.

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[6] For a detailed account of methods of testing sensory discrimination, see Whipple, "Manual of Mental and Physical Tests," 2d ed., 1914, part i, pp. 161–261.

Any correlational percentage above zero and less than a hundred means that there is some correspondence between the two traits measured, but not a perfect one. For example, consider the relationship between the ability to add and the ability to multiply. Let us suppose that we have secured, by the aid of addition and multiplication tests, two rankings of all the pupils of a class, one ranking arranging them in the order of their ability in addition, from the best to the worst, and the other arranging them in the order of their ability in multiplication. If the place of a child in one list was, as a rule, quite different from that which he occupied in the other, so that the two lists showed no more correspondence than would two lists made by drawing the names out of a hat, then the correlation between the two abilities would be zero. On the other hand, if the standing of the children in one list resembled their standing in the other list, we could say that there existed a correlation between the ability to add and the ability to multiply. The closer the resemblance in the standings of the children in the two lists, the higher the percentage of correlation. Were the standings in the two lists identical, the correlation would be perfect, or one hundred per cent. Lastly, and simply for the sake of illustration, should we find that the higher a child's rank in one list the lower it was in the other, we would say that the correlation was negative. Negative correlations, like positive, may vary all the way from zero to one hundred per cent.

Whenever the correlational percentage is less than one hundred, it indicates that the two traits considered are in part influenced by the same factors, but that, on the other hand, each of them is to some extent determined by factors which affect it alone. For example, to take a non-psychological illustration, we should find if we tabulated the price of corn and the price of pork throughout a number of years, a certain degree of correspondence or correlation, between the two. The price of one would tend to fall and rise with the price of the other. The correlation, however, would be far from perfect, because, although to some extent the price of corn and that of pork are determined by the same factors, each is affected in part by certain factors which do not disturb the other.

The Relation of Sensory Capacity to Intelligence.—This outline of methods leads us to the consideration of results. The early investigations of Krueger and Spearman[7] indicated that the correlation between sensory discrimination and intelligence was rather high. This accorded well with the emphasis so often given to sense training in the education of younger school children. Some of the theoretical conclusions of Krueger and Spearman, however, led to an investigation by Thorndike and some of his pupils.[8] The sensory traits tested were accuracy in estimating the length of lines, as indicated by the capacity to draw them equal in length to a standard, and accuracy in estimating weight, as shown by the capacity to reproduce a standard weight by filling a box with the necessary quantity of shot. As measures of the intelligence of the subjects, who were high school and normal school students, teachers' estimates of intelligence were used, along with the estimates of the intelligence of each other made by the students, and the average of their school marks. The correlations between these rather crude measures were much smaller than those of Krueger and Spearman, though still sufficient to indicate some slight degree of correlation between sensory discrimination and intelligence. Thus, for normal school girls, between estimates of length and teachers' estimates of intelligence, there was only twelve per cent. of correlation; between accuracy of weight estimation and intelligence as judged by teachers, no more than eight per cent.; and between accuracy of weight estimation and intelligence of the girls as judged by each other, twenty-four per cent.

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[7] "Die Korrelation zwischen verschiedenen geistigen Leistungs-Fähigkeiten." *Zeitschrift für Psychologie und Physiologie der Sinnesorgane,* vol. xliv, 1907, pp. 50–114. Also Spearman, "General Intelligence." *American Journal of Psychology,* vol. xv, 1904, pp. 201–293.

[8] Thorndike, Lay and Dean, "The Relation of Accuracy in Sensory Discrimination to General Intelligence." *American Journal of Psychology,* vol. xx, 1909, pp. 364–369.

Later investigators have tended to confirm the results of Thorndike rather than those of Spearman, on this point, in that they find but very small connection between sensory keenness and intelligence. Indeed, there seems to be no relation between intelligence and either the ability to notice small differences in weight or the ability to recognize as two, when applied to the skin, two points separated by a very short distance. Definite relationships appear to be established, however, for the so-called higher senses—those of vision and hearing.

A very interesting study of the relation of sensory discrimination to intelligence has been made by Burt.[9] His investigations were conducted among groups chosen from two schools of Oxford, England, one a superior elementary school and the other a high class preparatory school. Both groups were composed exclusively of boys ranging in age from twelve and a half to thirteen and a half years. As a measure of intelligence, Burt used the ranking of the boys by the Head-master. No assumptions were made as to the particular kind of capacity that should be called intelligence. This was left to the schoolmaster. "It was presumed," writes Burt, "that the schoolmaster was the proper person, if any, to know the original meaning of intelligence, to recognize it in the concrete, and compare its various degrees, even though the psychologist might prove the proper person subsequently to find for that meaning adequate expression, and to analyze and describe in technical terminology, the nature of the capacity denoted by it." [10]

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[9] "Experimental Tests of General Intelligence." *British Journal of Psychology,* vol. iii, 1909, pp. 94–177.

In view of Burt's confidence in the schoolmaster's estimates of intelligence, it is interesting to note the methods by which these estimates were made. In the elementary school, since the boys were in three different school grades, or standards, as they are called in England, the Head-master made three lists, based on the class marks, one for the boys of each standard; these three lists he connected by carefully dove-tailing the bottom boys of the upper standards with the top boys of the lower standard. He then thoroughly scrutinized the order, and further rearranged it from his private knowledge of the boys, with each of whom he was familiar. After an interval of several weeks, during which he frequently took lessons with the standards in question, he revised the list. When in doubt as to the relative position of two boys, his test-question was: "Which boy is the quickest at seeing the point of anything?" From his reputation as a judge of character, from his long personal experience of the boys concerned, and from the special interest, care and conscientiousness with which he performed the task, there can be little doubt that the grading is as nearly perfect as a grading based on personal impression can be.

In the preparatory school the Head-master used a somewhat different method. On the basis of class marks he produced two lists, in one of which the boys were ranked in the order of literary ability, and in the other in order of mathematical ability. From a fusion of these he derived a final order of general intelligence.

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[10] *Op. cit.*, p. 105.

The sensory tests used by Burt were four in number. One was a test of touch discrimination, consisting in the determination of the threshold for the discrimination of two points; that is, of the smallest distance apart at which two simultaneously applied points yield a double sensation. A second tested weight discrimination, that is, the discovery of the smallest noticeable difference in a weight of 100 grams. Sound discrimination was tested by determination of the smallest perceptible difference between two pitches. The fourth test, by determining the accuracy with which a standard line of ten centimetres could be reproduced, demonstrated ability to discriminate length of lines. The tests were repeated several times, and in general were carefully applied. The percentages of correlation between these sensory tests and intelligence, as estimated by the Head-master, are given in the following table:

CORRELATION BETWEEN INTELLIGENCE AND SENSORY KEENNESS

	Elementary School	Preparatory School	Average
Intelligence and touch discrimination....	17	–.17	.00
Intelligence and weight discrimination..	–.01	–.20	–.10
Intelligence and pitch discrimination....	.52	.41	.46
Intelligence and length discrimination...	.51	.44	.47

It will be noted that touch sensitivity shows no relation to intelligence, and that the capacity for weight discrimination bears a negative, or inverse, relation to intelligence; pitch and length discrimination, on the other hand, have a considerable positive relation.

Burt's results have been corroborated by other investigators. Thus, Carey,[11] who used several tests for each of the capacities of tactile, auditory and visual discrimination, found that the correlation between "practical" intelligence, as estimated by teachers, and tactile discrimination tests was slightly negative, whereas the correlation for discrimination of yellows—one of his visual tests—was twenty-three per cent., and for discrimination of pitches—an auditory test—twenty-four per cent.

Binet confirms Burt's notation of the inverse relationship between intelligence and the ability to discriminate between lifted weights. He observes that imbeciles have an amazingly keen power of weight discrimination.

Definitely positive correlations have been found also between intelligence and sensitivity to pain,[12] as measured by the amount of pressure on the ball of the thumb required to produce slight pain. Binet writes that "the threshold of sensibility to pain in the most intelligent pupils is lower than in the least intelligent; in other words, to provoke in them a minimum of pain requires a slighter pressure." "This finding," he continues, "compared with that which we have made upon our imbeciles, clearly shows that sensibility to pain develops with the intelligence; by pain we must here understand not only a sensation localized and appreciated in its intensity, but also all the psychic reverberations of this pain, the ideas and emotions it provokes, which increase it like an avalanche. In truth the highest intelligences have more merit in being courageous than grosser natures; they are in fact braver, though not by absence of fear, nor by obtuseness of the sensibilities, but by domination over a delicate sensibility." [13]

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[11] "Factors in the Mental Processes of School Children." *British Journal of Psychology,* vol. viii, 1915, pp. 86 and 88. See also Abelson, "Mental Ability of Backward Children." *British Journal of Psychology,* vol. iv, 1911, p. 303.

[12] Binet and Simon, "L'intelligence des imbéciles," *L'année psychologique,* vol. xv, 1909, pp. 52–58; Carman, "Pain and Strength Measurements of 1507 School Children in Saginaw, Michigan," *American Journal of Psychology,* vol. x, 1899, pp. 392–398; and Swift, "Sensibility to Pain," *American Journal of Psychology,* vol. xi, 1900, pp. 312–317.

In general, then, correlation between intelligence and ability to make fine sensory discriminations is slight. The exact degree of correlation, even in the case of any one sense, will depend upon the exact kind of discrimination tested. Thus, discrimination of color tones manifests a higher correlation with intelligence than does visual acuity. In general, however, keenness of vision, hearing and sensitivity to pain are valuable assets, because such sensitivity, and the capacity for discrimination of color tones, lengths of lines and tone pitches show fairly definite, though low, correlations with intelligence. On the other hand, the capacities for fine tactile discriminations and for fine discriminations between lifted weights display either no correlation or an inverse correlation with intelligence. Therefore, practically no relation exists between capacity for fine weight and tactile discriminations and capacity for general success.

Comparison of the Senses of Primitive and Advanced Races.—However, the ability to make fine weight discriminations is not an undesirable capacity. This fact makes the negative correlation with intelligence an exceedingly interesting problem, for in general, desirable mental traits show a positive correlation with intelligence and with each other. The explanation is no doubt to be sought in man's evolutionary history. Thus it may be supposed that at one stage of evolution this capacity, like the capacity for fine smell discriminations in the dog, was of great service. It may not have been exactly the capacity for making fine weight discriminations, but some capacity inseparably connected therewith, possibly some muscular or motor capacity. At this stage in evolution a positive correlation must have existed between capacity for weight discrimination and intelligence. Then the direction of evolution changed. Man came to live a life in which an exceptional development of this capacity did not particularly help those possessing it to survive in the struggle for existence. Evolution consisted in the development of other capacities.

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[13] "The Intelligence of the Feeble-Minded," by Binet and Simon. Translation by Elizabeth S. Kite, 1916, p. 65.

Any capacity no longer important in the maintenance of the species would have no guarantee of preservation. Individuals possessing it in a low degree had the same chance to survive as those possessing it in a high degree. Such a capacity, consequently, deteriorated, while other ones, more related to intelligence, were becoming perfected. It might thus happen that those capacities, such as weight discrimination and tactile discrimination, which show no positive correlation with intelligence in the advanced civilized races, came to be capacities in which the more intelligent individuals were often surpassed by the less intelligent, and the highly developed races by the more primitive, savage ones.

That savages may excel the more intelligent races in those traits which are not definitely correlated with intelligence in the white man is not merely a theoretical conclusion. It is a fact demonstrated by numerous observations, among the most remarkable of which are those made by the Cambridge Anthropological Expedition to Torres Straits. These straits, lying between British

New Guinea and Australia, are inhabited by Papuans. The distinguished English psychologists who took part in the expedition set up a small psychological laboratory in a deserted missionary house on Murray Island, where for four months they conducted a number of tests among the natives. The people were sufficiently civilized to coöperate with the psychologists, although they were very primitive—not far removed, indeed, from complete savagery, the first civilized teacher having landed on the island as late as 1871.

In touch and weight discrimination the primitive Papuans were found superior to Englishmen. In the skin areas tested, the Murray Islanders had a threshold of tactile discrimination of which the value, in terms of distance between the two points touched, was just about one-half that of Englishmen. In other words, their power of tactile discrimination was about double that of Englishmen. A somewhat similar, though less striking, result, was obtained in the case of discrimination of weight; the Murray Islanders could distinguish a difference of 3.2 per cent., whereas thirty Englishmen tested in the same manner could discriminate only a difference of 3.9 per cent. "The power of discrimination of small differences in weight," writes McDougall, the member of the expedition who made these tests, "appears therefore to be rather more delicate in the Murray Islanders than in Englishmen."[14]

Pitch discrimination, on the contrary, which has been found to correlate positively with intelligence in white people, was markedly superior in the Englishmen. Myers, using a standard tuning-fork of 256 vibrations, found the barely perceptible difference in pitch for Murray Island children to average 12.5 vibrations, whereas for Scotch children of Aberdeenshire he found an average as low as 4.7 vibrations.[15] The pitch discrimination of the Scotch children was therefore better by eight vibrations than that of the Murray Island children. The ability of savages to hear at a distance the ticking of a watch was also inferior. Likewise, the sense of pain, keenness of which correlates with intelligence, was dull in the Papuans and keen in the white races. But the Papuans were not more lacking in sensitiveness to pain and acuteness of hearing than the Filipinos, the Patagonians, Africans, the Ainu and other supposedly primitive races.[16]

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[14] "Reports of the Cambridge Anthropological Expedition to Torres Straits," vol. ii, part ii, 1903, p. 198.

Perception.—Passing now to the consideration of other mental capacities, we may inquire whether the capacities for perception, imagery and feeling are more closely identified with intelligence than is the capacity for sensory discrimination. It must be answered that on these functions the data are too meagre to justify very definite conclusions; but they indicate, at least, that the correlation existing between intelligence and perceptions and imagery is no higher than for sensory discrimination.

Tests involving the essential part of the perception process have not as yet been employed. The important thing about a perception is that the impression derived from any object should immediately revive, and unite with, the proper associates. Thus, the sound made by an object as it moves or as it is dropped, should revive its visual appearance, its feel to the touch, and its name.

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[15] *Op. cit.*, p. 168. The results quoted were those obtained at the children's second sitting.

[16] See Woodworth, "Racial Differences in Mental Traits," *Science*, vol. xxxi, 1910, pp. 171–186; and Bruner, "The Hearing of Primitive Peoples," *Archives of Psychology*, No. 11, 1908.

To test the accuracy of the perceptual processes, then, it seems necessary to use tests in which objects are presented to one sense, but the judgments required are based on the associated impressions derived through other senses. For example, a number of objects might be placed before a child, such as an axe, a dish-pan, a roll of cotton, and a base-ball. Then without touching them, he should be asked to indicate the heaviest, the next heaviest, and so on down to the lightest—the experimenter arranging them in the order indicated. Again, one may show a child a number of carefully chosen, familiar objects, then have him close his eyes, and name them merely from the sound they make as they are dropped upon the table. These tests resemble the game of guessing the name of a person caught by one who is blindfolded. A great variety might be devised. How they would correlate with measures of intelligence it is impossible to say, as the necessary investigations have not been made.[17]

Tests of perception so far performed show that in certain aspects, at least, perception correlates but slightly with intelligence. Illustrative results have been obtained with the cancellation test.

The cancellation test consists of a number of lines of letters printed in capital letters. The letters are equally spaced and arranged in a miscellaneous, meaningless order. The subject tested takes a pencil and, running along the letters as in reading, makes a line through a designated letter every time he meets with it. Because some of the letters that should be marked may be omitted, and others may be marked by mistake, there are various ways of scoring the test other than by taking simply the number of letters correctly cancelled in the allotted period. The result depends very much on whether the test is graded simply for speed, for accuracy, or for both. As might be expected, there is a tendency for those who work fast to be less accurate than those who work slowly, and there appears, further, to be a tendency on the part of the brighter children to seek accuracy rather than speed. When the test is graded for speed, it is likely to give a negative correlation with intelligence. I gave this test to one hundred Minneapolis ten-year-old school children whose intelligence had been measured by Terman's revision of the Binet-Simon scale. Grading for speed only, I found a negative correlation with intelligence of –.16. This agrees with the results of others who have found the test to correlate negatively with school marks[18] and with tests which are known to correlate highly with intelligence.[19]

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[17] Tests of this sort are now being used successfully by Dr. Frances Lowell, of the University of Minnesota, as one of a number of group intelligence tests.

Now it cannot be denied that the cancellation has sometimes shown positive correlations with intelligence. It is particularly likely to do so when complicated by the requirement of cancellation of several letters instead of merely one, and when accuracy is given due weight in the grading. On the whole, however, the results obtained with this test may be regarded as indicating that neither great speed nor great accuracy of simple perceptual processes is of any advantage as far as intelligence is concerned. Of course this conclusion does not mean that perception is of little advantage. Both sensation and perception are indispensable to intelligence; but refinement beyond a certain minimum, while it may be of advantage in certain special pursuits, is of no aid to success in general.

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[18] Whipple, "Manual of Mental and Physical Tests," 2d ed., part i, p. 324.

[19] McCall, "Correlation of Some Psychological and Educational Measurements," 1916, p. 49.

Imagery.—The capacity for imagery is difficult to investigate, but very exhaustive and painstaking studies of imagery in children have nevertheless been made. It has long been established, by patient questioning, that children employ concrete imagery much more than do adults. Children picture to themselves the actual object, whereas adults think more in terms of symbols of objects, especially in mere words. The substitution of symbolic or abstract images for concrete ones occurs gradually, but judging from comparative studies of children and adults, the change is most marked at about the age of thirteen to fourteen. Before the age of puberty the normal child thinks characteristically in concrete terms, in terms of particular instances. Childhood is, and should be, a period for the acquisition of a host of detailed, accurate perceptions and images. Greater wealth of such acquisition in childhood provides a better foundation for adult abstractions. A precocious tendency towards the use of abstract thought is therefore not a promising sign. According to Meumann, a very distinguished authority, precocity in this respect is characteristic of dull children, whereas the more intelligent are best represented by the tendency to use concrete images.[20]

On the relation of intelligence to clearness or distinctness of children's imagery, the most valuable evidence has been obtained by Carey.[21] His investigations concentrated upon the clearness of imagery by a large number of experiments, each of which required the child to make introspective judgments concerning the clearness of his images. As an illustration of his method, we may cite the following one of eight tests used for visual imagery:

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[20] "Intelligenzprüfungen an Kindern der Volkschule," *Experimentelle Pädagogik*, vol. i, 1905, p. 93.

[21] "Factors in the Mental Processes of School Children," part i, "Visual and Auditory Imagery." *British Journal of Psychology*, vol. **vii**, 1915, pp. 453–490.

3. THINK OF THE FIRE ENGINE

Can you picture the firemen? Clearly, fairly clearly, or dimly?
Can you count them? Clearly, fairly clearly, or dimly?
Can you picture the horses galloping to a fire? Clearly, fairly clearly, or dimly?

Before the experiment, some pains were taken to explain the various degrees of clearness. "Each child was asked to look at a particular object in the room and then to shut his eyes and compare the clearness of the image with that of the object, and an endeavor was made to make the meaning of the terms 'clear,' 'fairly clear,' and 'dim,' as definite as possible. 'Clear' was to mean that the image was as plain as the object itself. 'Fairly clear' was to mean that the image was not so plain as the object, but that it could be maintained without much effort. 'Dim' was to mean that the object could be pictured, but that it was 'shadowy,' and kept coming and going." The introspection of mental processes is usually considered too difficult for children, but in the task cited is fairly simple, and a special study made by Carey indicated that the introspections were sufficiently reliable for his purpose. He writes that "not a single case occurred of a child who appeared to have failed to understand or to be unable to answer." [22]

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[22] *Op. cit.*, p. 480.

The marks obtained from these tests of imagery were compared with a ranking of children according to "scholastic" and "practical" intelligence drawn up by the teachers, and also with the marks obtained in the various school subjects. The correlations were found in all cases to be very low. Between teachers' estimates of intelligence and the clearness of the different sorts of imagery, what little correlation there was tended to be negative. The correlation with marks in particular school subjects was sometimes slightly positive and sometimes slightly negative, but averaged very nearly zero. Painting was the only school subject found to show a positive correlation with imagery, and even this correlation was low.

The findings of Carey conform with those of other investigators. Rusk, for example, concludes that "Children who are best endowed with respect to the various forms of imagery do not, it would appear, necessarily stand highest in school."[23]

The low correlation between clearness of imagery and intelligence is not particularly difficult to understand. It is commonly assumed that every type of mental process involves the use of imagery. This may be true, although its application to thought processes is questionable. But in thinking and reasoning, imagery functions solely as a symbol. Almost any image can be used as the vehicle for any thought, just as different sounds or words are used in different languages, all to indicate the same object. Admitting, then, that imagery of some sort is indispensable in all mental operations, it must be conceded that in general the sort of imagery, visual or auditory, distinct or vague, is of little import.

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[21] "Mental Association in Children." *British Journal of Psychology,* vol. iii, 1909–1910, p. 385.

Feelings.—In addition to sensations and images it is customary to recognize a third type of elementary mental processes, namely, the feelings or "affections" of pleasantness and unpleasantness. There is considerable disagreement among psychologists concerning the status which a systematic psychology should assign to these processes. The commonest opinion is that they are neither sensations nor attributes of sensations, but are a separate class of mental elements. They are usually distinguished sharply from the more complex processes called emotions —joy, grief, fear, love and anger.

There is general agreement concerning the feelings on two points of importance in connection with intelligence. First, there exists a very strong, inborn tendency to do those things which give pleasure, and to avoid those which produce unpleasantness. In accordance with this tendency is the recognized educational principle that "acts which are to be repeated, ends that are to be achieved, and behavior that is to be confirmed, should be made as pleasurable in their consequences as possible."[24] The second point generally agreed upon is that pleasantness is usually the sign of an efficient and beneficial functioning of the nervous system, while unpleasantness signifies the reverse. As a rule, the pleasurable things are those which are beneficial, and the unpleasant those which are harmful. Now since the tendency is to do the pleasant things and avoid the unpleasant, it is evident that the feelings, in spite of their waywardness, of themselves afford an indispensable guide to correct behavior.

On general grounds the feelings thus appear to play an important part in the determination of behavior, but observations to prove their correlation with intelligence are few and far between. So far as they go, however, these observations indicate a very considerable relation. It has been frequently noted that feeble-minded children are below normal in the strength of their feelings, and that their feelings are often perverted, or out of harmony with the object producing them. According to the observations of Sherlock, defectiveness of the feelings is more or less proportionate to the degree of feeble-mindedness.[25] This agrees with the result noted earlier in this chapter that sensitivity to pain appears to be definitely correlated with intelligence. Pain, to be sure, is a sensation, and not the same thing as the feeling of unpleasantness; yet pain is almost invariably accompanied by unpleasantness, and sensitivity to it is probably closely correlated with acuteness of feeling.

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[24] Colvin and Bagley, "Human Behavior," 1913, p. 91.

An interesting study of the feelings was made by Wylie, by taking advantage of the well-known fact that bodily changes invariably accompany the feelings. By means of apparatus which recorded the breathing, he studied the effect upon children produced by an unpleasant sensation. The sensation used in most cases was that of the taste of quinine. The disturbance produced in the breathing was found to be very slight in imbeciles, but increased to a very marked degree as the children approached the normal in brightness.[26] He made no experiments to test the effect of pleasure, but his observations led him to believe that pleasantness is likewise less intense in feeble-minded children.

This completes a survey of the relationship between intelligence and the elementary mental processes. Except in the case of the feelings, on which data are very scarce, the relationship is obviously not very close. This does not mean that the elementary processes are unimportant. Without the elementary processes there could be no complex ones. It means merely that great refinement in the simple mental operations is no great asset. Their development beyond a certain point is of little general value. The important thing is the arrangement and organization of the mental processes—the interrelationships that exist between the simpler processes and the degree of their co-operation in the carrying out of the more complex mental operations. Of all the forms of interrelationship between mental processes, the two most fundamental are those of association and attention, now to be considered.

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[25] "The Feeble-Minded," 1911, pp. 74–76.

[26] "Instincts and Emotions of the Feeble-Minded." *Journal of Psycho-Asthenics,* vol. v, 1901, p. 105.

CHAPTER IX

ASSOCIATION, MEMORY AND ATTENTION

If a single word is pronounced to a person prepared to give it attention, it will at once call to his mind various related words and ideas. These ideas in turn will summon still other ideas, and so the process of thought will continue until interrupted by some external event which catches the attention and initiates another series of ideas. The entire course of thought, including all the complex processes of imagination, judgment and reasoning may be analyzed into a set of sequences of one idea upon another. The occurrence of one idea, or of any mental process in sequence upon, and as the result of, another, is called an association. Since all thinking is made up of a multitude of such sequences, clearly the processes of association must pervade the entire intellectual life.

In its simplest forms, association is studied mainly by two methods—that of free association and that of controlled association. In the free association method, the subject allows to come into his mind whatever associations may spontaneously arise. In the controlled association method, on the other hand, the associations of the subject are guided by instructions from the examiner. Instead of coming and going without direction, the associated ideas must stand in some prescribed relationship to each other—cause and effect, similarity, or contrast.

Free Association.—The most widely used procedure in the free association method is that introduced by Jung.[1]

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[1] "The Association Method." *American Journal of Psychology*, vol. xxi, 1910, pp. 219–270.

A list of common words, called stimulus words, is pronounced to the pupil, who has been previously instructed to reply to each word as quickly as possible with the first word that it brings to mind. The examiner gives a few carefully chosen illustrations, to begin with, somewhat in this fashion: " When I give you a word, for example, *rat,* you answer just as quickly as you can with the very first word that comes into your head, no matter what it is—it may be mouse or cat, or it may be cheese, floor, hole or chimney, or something that doesn't make any sense at all, like hat or teacher. Never reply by more than a single word." The reply is made orally when the test is given to the children individually, and in writing when the test is a class experiment.

Upon careful examination the replies received with a list of one hundred words are found to be surprisingly interesting and illuminating. Peculiar associations generally signify some peculiarity in the child's previous experience, since it is a fundamental law of association that one idea cannot call up another in immediate sequence to itself unless the two have been connected in some previous experience. An analysis should consequently be made of all peculiar associations by persuading the child to recall in detail the experiences which explain them. When the tests are given individually, it is also important to note those in which the response is a long time forthcoming, and to analyze these also, particularly to determine whether or not the delay is due to any strong emotional connections.

I have found this analysis of the peculiar and hesitating responses particularly valuable in the study of juvenile court cases. For example, I once gave the free association test to a thirteen-year-old boy accused of having stolen some copper wire. He obstinately denied the theft. In a long list of stimulus words, I inserted the word *copper* and immediately afterwards the word *wire*. To the word *copper*, the boy replied promptly with *cut*—a peculiar response; but at the word *wire*, he became confused, and after about thirty seconds responded with *garage*. When I asked him why *wire* suggested to him *garage*, the young delinquent knew that he had betrayed himself, and immediately confessed.

The results of the free association test can be adequately interpreted only with the aid of "association frequency tables." These tables show the responses to a given stimulus word, and the number of times each one occurs among the responses of one thousand individuals. It has been found that the same word pronounced to one thousand persons does not bring out one thousand different responses. For example, to the word *dark*, over four hundred out of a thousand children will respond with the word *night*, and to the word *scissors*, about eight hundred out of a thousand will respond with the word *cut*. Besides the most frequent response, there are always many others, so that, on the average, something over one hundred different responses will be obtained from one thousand children. A frequency table shows the number of children in one thousand giving each of the responses.

As an illustration, I may give the following frequency table[2] compiled from the responses of Minneapolis school children from nine to twelve years of age, to the stimulus word, *fun*. The favorite response is *play*, given by 394 children. Before each response is placed the number of children giving it.

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[2] See Woodrow and Lowell, "Children's Association Frequency Tables." *Psychological Monographs*, No. 97, 1916, p. 41.

Responses to the Word Fun by One Thousand School Children

2 bad
35 ball
7 baseball
5 basketball
1 box
4 boy
10 boys
2 build
1 bun
1 butter

1 can
1 cap
4 cheery
2 child
13 children
1 clock
1 cookie

3 dark
1 delight
2 delightful
4 digging
2 dirt
1 doll
9 dolls
3 doors
1 down
1 drowned

2 eat
5 eating
1 enjoy
2 enjoying

2 fall
2 fell
3 fight
1 finger
9 fishing
1 food
15 football
3 frolic
3 full
5 funny

12 game
38 games
1 gay
1 girl
2 girls
4 glad
9 good
4 good time
1 ground
4 gun

1 had
16 happy
4 happiness
17 have
11 hide-and-seek
4 hockey
2 hop
3 hurt

1 I
1 it

3 jokes
1 joking
6 jolly
29 joy
6 jump

18 laugh
2 laughed
3 laughing
1 light
5 like
5 lots
3 lunch

6 marbles
2 money
1 much

8 nice
2 noise

2 outdoors
1 outside

394 play
34 playing
4 pleasure

3 race
2 ran
1 rat
2 read
3 recess
3 rope
46 run
1 running

4 school
1 see
1 sew
2 shovel
2 show
4 skate
1 skates
11 skating
3 sled
2 slide
5 snow
6 snowball
6 snowballs
2 snowfight
4 sport
7 swimming

22 tag
2 time
2 toy
1 toys

1 very

2 walk
1 water
1 well
1 window

Frequency tables have been compiled on an elaborate scale both for adults [3] and for children,[4] so that interesting comparisons may readily be made. How striking is the difference between the two groups may be seen by comparing their commonest responses. These responses are given in the accompanying table for ten words, chosen as among the words for which the difference is greatest.

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[3] Kent and Rosanoff, "A Study of Association in Insanity." *American Journal of Insanity,* vol. lxvii, 1910, Nos. 1 and 2.

[4] Woodrow and Lowell, *op. cit.*

The frequency of the commonest response of each group is given in italics. For each of the commonest of one group, is given in plain type the corresponding frequency of the other group.

Comparison of the Frequencies of Favorite Responses in One Thousand Adults and One Thousand Children

Stimulus word	Response	Adults	Children
1. Table	chair	*267*	16
	eat	63	*358*
2. Sickness	health	*142*	6
	doctor	62	*116*
3. Man	woman	*394*	8
	work	17	*168*
4. Girl	boy	*350*	40
	dress	8	*240*
5. Deep	shallow	*180*	6
	hole	32	*257*
6. Needle	thread	*160*	72
	sew	134	*449*
7. Sleep	rest	*300*	40
	bed	75	*351*
8. Stomach	food	*102*	82
	ache	31	*189*
9. Doctor	physician	*213*	6
	sick	52	*448*
10. Hand	foot	*204*	0
	fingers	83	*130*

A careful study of a list of one hundred responses, particularly when frequency tables are at hand for comparison, is often valuable in forming an estimate of a child's intelligence. Among the special characteristics which distinguish the associations of the less intelligent from the more intelligent are the following five: (1) The less intelligent frequently misunderstand or misinterpret the stimulus word. (2) They often fail to give a response. (3) They offer a number of senseless responses—the response word standing in no apparent relation to the stimulus word. (4) Their responses give evidence of less mental effort, being sometimes only a changed form of the stimulus word, as wish—wishing, or a meaningless sound association, as fruit—boot. (5) Their responses are likely to show mental inertia, of which there are two main types. First, the response may consist in the simple repetition of a previous stimulus word or of a previous response word. Second, a stimulus word may start a train of ideas, which persists and determines the succeeding responses independently of the stimulus word. Illustrating this latter sort of inertia, one dull boy responded to *house* by *barn;* then to *black* by *horse;* then, without reference to the stimulus word, to *fun* by *cow;* and so on. In this case the boy's mind was on the animals in the barn, and no matter what word was pronounced to him, he continued to respond by something connected with the topic then dominating his thought.

When a more quantitative expression of the integrity of the association processes is desired, that is, a measurement that can be expressed in numbers, the best procedure is probably that suggested by Römer.[5] It involves going over the responses of each child and checking off every "favorite" response. A favorite response is the one which has the highest frequency in the frequency table for the corresponding stimulus word. According to Römer, a conspicuously small number of favorite responses indicates inferiority of intelligence. He finds that the great majority of mentally retarded children respond with a smaller number of favorite responses than do three-fourths of normal children of the same chronological age.

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[5] "Associationsversuche an geistig Zurückgebliebenen Kindern." *Fortschritte der Psychologie und ihrer Anwendungen,* vol. iii, 1914, pp. 43–101.

In view of all its possibilities the free association test has been regarded as one of the most valuable single tests yet devised. Its chief worth lies in the opportunity it affords for psychological analysis, and in its picturing of a child's mental make-up. In these respects it is superior to the controlled association tests. The latter give a ranking, a number, but, like many other mental tests, little more.

Controlled Association.—The controlled association tests, although they do not intimately reveal the nature of the child's mind in the manner of the free association tests, give measures very closely correlated with the child's brightness. To a certain extent, they may be regarded as tests of the organization of associations, or rather of the degree of discipline within that organization. They test the ability to perform the right mental operation at the right time, a power of obvious importance. Controlled association tests are numerous. I shall mention only two, the " opposites " test and the " completion " test.

The opposites test is one of a number, in which the subject must respond to the stimulus word not simply with whatever word occurs to him, but with a word standing in some prescribed logical relation to the stimulus word. In the opposites test, the response must consist of a word meaning the exact opposite of the stimulus word. Below are given two parallel lists of stimulus words, arranged, on the basis of tests with six hundred children, so as to run parallel in difficulty. Each list proceeds from easy words to hard ones, and may be used in any grade above the second.*

List I	List II
yes	rich
in	young
new	east
north	empty
heavy	dead
sharp	sour
weak	wild
love	less
best	buy
over	friend
push	broad
much	increase
tender	strength
false	generous
rude	like
stormy	part
bless	silly
frequently	refined
injurious	permit
strict	simple

Exceedingly high correlations with intelligence have been demonstrated by data obtained with such tests. A number of experimenters have worked out percentages of correlation in the neighborhood of eighty.[6] Both pedagogically retarded and feeble-minded children fall definitely below the normal ones in this test, in speed as well as in quality of response.[7]

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*These lists were worked out by Miss Grace Arthur, Psychologist in the Public Schools, Chrisholm, Minnesota, while a graduate student.

[6] Bonser, "The Reasoning Ability of Children," 1910, p. 101; and Simpson, "Correlations of Mental Abilities," 1912, p. 75.

The completion test correlates as highly with intelligence as does the opposites test. It consists of a passage of prose in which certain words have been omitted. Each omitted word is represented by a blank, which the subject is required to fill with a word that makes good sense. The associations are thus controlled by the context. While the completion test, from the psychological point of view, may best be classified as a test of controlled association, it cannot be denied that success in it is also to some extent dependent upon imagination and linguistic ability. Almost any text can be adapted for use as a completion test. Passages from school texts already studied by the pupil, or other passages based thereon, when converted into completion tests, may serve excellently in place of the ordinary type of examination questions. If the right words have been omitted, only a child with the requisite comprehension of the subject will be able to fill in the blanks correctly. For psychological purposes a great variety of texts have been used.

The best known of the completion tests, perhaps, are those used by Trabue as measures of the language ability of school children. There are a number of sets of these, two of which are here reproduced, the one, *Scale B,* for younger children, the other, *Scale L,* for older children.[8] Only one word is to be written in each blank.

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[7] Squire, "Graded Mental Tests," *Journal of Educational Psychology,* vol. iii, 1912, p. 431; and Norsworthy, "The Psychology of Mentally Deficient Children," *Archives of Psychology,* No. 1, 1906, pp. 59–62.

[8] Published and copyrighted by Teachers' College, Columbia University, New York City.

THE TRABUE LANGUAGE TESTS

Scale B

1. We like good boys........girls.
2. The........is barking at the cat.
3. The stars and the........will shine to-night.
4. Time........often more valuable........money.
5. The poor baby........as if it were..........sick.
6. She........if she will.
7. Brothers and sisters........always........to help........other and should........quarrel.
8. ....weather usually........a good effect........one's spirits.
9. It is very annoying to ....tooth-ache, ...often comes at the most........time imaginable.
10. To........friends is always........the........it takes.

Scale L

1. Children........are rude........not easily win friends.
2. Plenty........exercise and........air........healthy.......and girls.
3. In........to maintain........health, one should have nourishing........
4. ....happiness cannot be........with money.
5. One's........do........always express his thoughts.
6. To........to wait, after having........to go................. very annoying.
7. It is sometimes........to........between two........of action.
8. One can........do his........at one........while........of another.

Memory.—Closely related to the tests of controlled association are those ordinarily used for measuring memory. Every act of memory is one of controlled association. A remembered word or idea comes into mind through association with some other idea, and memorizing consists simply in the formation of associations. Thus, in memorizing a French-English vocabulary, the process is one of establishing associations between the French words and the corresponding English words; and memory for such a vocabulary is tested by giving the French words to determine whether or not they call up the right association. In such tests, the associations are even more strictly controlled than they are in the opposites test; for although a word may have several fairly accurate opposites, a given French word has only one correct translation. The process of memorizing a connected passage consists in forming associations between each word or phrase and the succeeding ones. It is evident, then, that memory tests might very properly be grouped under tests of controlled association.

The difference between association tests and memory tests is that in the former the associations brought to light by the test have been formed in the individual's past experience, before the test is given to him; whereas in the latter they are formed under the control of the examiner. The association tests appraise the organization of associations formed in the past under more or less vague conditions, whereas memory tests reveal the power of forming associations by determining their strength after a definite and carefully controlled period of study.

It is irrefutable that an individual may remember one class of facts or objects much better than he does others. It follows, then, that to obtain an accurate idea of any individual's memory, a number of tests must be given so as to include a considerable variety of memory materials. A variety of methods should be used. In general, memory is tested by presenting to the subject for study certain memory material, and afterwards calling upon the subject to reproduce the material, which may be either visual or auditory, that is, either seen or heard, and may consist either of words or of objects, such as pictures or geometrical diagrams. The subject may reproduce this material by any possible means of expression, by speech, by writing, by drawing, by pointing, or, with musical material, by whistling. singing, or playing upon some musical instrument. Three chief types of procedure may be followed. These are, the method of right associates; the method of amount retained; and the learning method. There are drawbacks as well as advantages to each of them.

The method of paired associates is in some ways the most satisfactory. Words, numbers, colors, or even concrete objects may be used as the units to be memorized. They may be presented to either the eye or the ear, hence let us suppose that spoken words are to be used. Pairs of words are read to the children, who are required to repeat each pair out loud before the following pair is read. The list, which may be of any desired length, is sometimes repeated more than once. Then the first words of the pairs are read alone, in a new order, and the children write down the other word of each pair. It is much like the procedure used in testing an English and foreign language vocabulary, in which each foreign word has its English associate, but differs therefrom in that both members of each pair are English words and the number of repetitions is controlled by the examiner. A good variation of the method is to give a number to each of a list of words, then, after reading both the words and their numbers, to read the words only and ask the children to write down the numbers. In all cases the measure of memory is the number of second members of the pairs written correctly, that is, the number of right associates. As in all memory examinations, the testing proper may be postponed to any desired time after the original presentations of the material.

The method of amount retained, in the broadest sense, may be said to include all the other methods. It is ordinarily used, however, to designate the testing of memory simply by presenting material once or oftener, and then taking as the measure of memory the amount (number of words, digits or other elements) that the subject can correctly reproduce. Material commonly used consists of short prose passages of uniform difficulty throughout, or of lists of words, digits or letters. The largest number of such elements that can be correctly reproduced after one presentation is known as the memory "span." It is determined by beginning with a short series, say of three words, easily reproduced, and gradually increasing the length of the series, one element at a time, until they are of such length that they can no longer be reproduced correctly. The greatest length of series that is reproduced correctly in two trials out of three may be taken as the memory span.

The third method of measuring memory is the learning method. Somewhat difficult to control accurately, it is nevertheless a useful method. Its object is to determine the amount of study, measured either in terms of time or number of repetitions, required to learn a given material just well enough to be able to reproduce it without error. According to this method the child who can correctly recite a verse of poetry after the shortest period of study has the best memory of his class.

These methods, with numerous modifications of them, have been used extensively in studying the importance of memory in respect to intelligence. A very considerable degree of correlation has been discovered. Brown tested memory for poetry and for nonsense syllables in London schools, and found correlations in the neighborhood of fifty per cent. with school marks and with general intelligence as estimated by teachers.[9] Some investigators have found lower,[10] others higher,[11] correlations. In general, good memory seems more essential to a high order of intelligence than the ability to make fine sensory discriminations, but less important than the organization of associations as tested by the opposites test or the completion test.

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[9] "Some Experimental Results in the Correlation of Mental Abilities." *British Journal of Psychology*, vol. iii, 1910, pp. 296–322.

One of the best ways of determining the importance of any mental capacity as a factor in intelligence is to determine to what extent its impairment parallels the enfeeblement of intelligence. This method has been employed in a number of investigations of memory in the feeble-minded. Johnson may be quoted as representative; he writes of the memory span:

"The results of the memory tests show that the feeble-minded fall considerably below normal children in memory span. But the memory span is so good in some cases, and the average for the majority so high, that we are led to conclude that the degree in which the memory span of feeble-minded children falls below that of normal children is not commensurate with the degree in which the feeble-minded fall below normal children in general intelligence. Moreover, it is evident that the deficiency in attention and will-power, so proverbial in the feeble-minded child, would tend to cause the memory span to be lower than that which a normal child of equal physiological retentiveness of memory would have. Hence we may conclude that weakness of memory, physiologically speaking, is not a specially prominent factor in feeble-mindedness."[12]

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[10] Carey, "Factors in the Mental Processes of School Children," part ii. *British Journal of Psychology*, vol. viii, 1915, p. 88.

[11] Burt, "Experimental Tests of General Intelligence." *British Journal of Psychology*, vol. iii, 1909, pp. 141–145.

[12] "Contribution to the Psychology and Pedagogy of Feeble-Minded Children." *Journal of Psycho-Asthenics*, vol. ii, 1897, pp. 68–69.

In addition to the fact that memory is dependent upon attention and will-power, it should be noted that to a certain extent memory also involves the capacity for rational reconstruction. If certain items of a short story are remembered, an intelligent person can fill in others from imagination, and so reconstruct the story, if not in its original form, at least in such a way as to make good sense. The feeble-minded confuse a story hopelessly—so that it is a jumble of words without meaning—showing themselves to be very weak in the capacity for putting together in a logical way items which they may contrive to remember. It is, of course, less desirable to remember well than to remember the right things. It takes judgment to decide what is worth remembering. It is not memory in itself, but the use that is made thereof, which determines intelligence. Consequently, it is easy to understand why memory ability, in spite of its enormous value, falls so far short of perfect correlation with intelligence.

Attention.—Attention, like association, is fundamental. It shares in every mental operation. It is the great steadying and directing factor of the mind. Association is the process whereby the stream of mental events continues to run its course; attention is the process which directs the stream to a certain course, and thus, holding it in bounds, preserves its force and vigor, instead of allowing it to be dissipated by aimless meanderings in any direction.

Good attention means devotion to the business at hand. It amounts to a surrender of the mind to the object of interest, so that the latter takes complete possession. This object of interest may be an external spectacle or the solution of an abstruse problem, but, whatever it may be, the greater the degree of attention directed to it, the greater the amount of mental energy thereby absorbed. Mental energy is monopolized by one set of mental operations, which thus reinforce themselves at the expense of all conflicting ones, and, by so doing, acquire greater strength and efficiency, manifested by the success of the actions to which they lead.

The difference between good attention and bad attention is primarily a matter of degree. In dull children, the degree of attention is weak; power of concentration is lacking. Inability to resist distractions accompanies this general feebleness of attention. Every little external occurrence is a successful but short-lived claimant of mental favor. There is no loyalty to any one purpose. Occasionally, but rarely, children show exceptional irregularity of attention, the degree of attention being good as a rule, but at times very poor. In these cases an attempt should be made to ascertain the cause of the marked irregularity. It may be necessary to consult a physician.

To estimate the degree of attention of which a child is capable is exceedingly difficult. The teacher can judge of a child's attention only by his demeanor, and this is very misleading. In general, no doubt, the child who keeps his eyes on his work and appears to be absorbed in his occupation is paying better attention than one who fidgets about. And no doubt it speaks well of the power of attention of the pupils in a class if it is easy to secure perfect quiet from them. A great difference between the second grade and the eighth grade is noticeable in the amount of scuffling of the feet while the class is attentively at work. But these signs at best lead to no better than a rough estimate of attention, and not to accurate measures.

The principle on which are based most of the scientific methods for measuring attention is that the higher the degree of attention to a specified task, the greater the resistance to distraction.[13] The subject's efficiency in some mental work is first measured under highly favorable conditions, and then under distraction. The greater the decrease in his efficiency as the result of distraction, the poorer his attention. The distraction may be produced by requiring the subject to carry on some other mental work simultaneously with the principal mental work, or merely by some modification in the conditions of the work, so that greater attention is required to attain the same results. The dotting test is a good illustration of this latter method, in which the distraction (or, as I prefer to say in this case, the *detraction*) consists simply in an increase in the difficulty of the conditions under which attention must be given.

The dotting test, used by Burt upon school children,[14] is far from being purely a test of attention. It does not measure attention apart from other factors. Nevertheless it makes great demands upon attention. The task of the pupil in this test is to mark with a pencil each dot of an irregular zigzag row, printed upon a paper tape, as shown in figure No. 9. The tape is seen through a small window, past which it is carried by a small drum rotated by clock-work. The task can be made more and more difficult by increasing the speed of the drum.

"The subject watches and marks the dots as they appear through the window, and are carried past to his left. Each act of dotting constitutes a discrimination reaction, and a spell of dotting constitutes a series of such reactions performed at full, or nearly full, speed. . . .

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[13] See Woodrow, "The Measurement of Attention," *Psychological Monographs*, No. 76, 1914, p. 158; also "Outline as a Condition of Attention," *Journal of Experimental Psychology*, vol. i, 1916, pp. 23–39; and "The Faculty of Attention," ibid., vol. i, 1916, pp. 285–318.

[14] "Experimental Tests of General Intelligence." *British Journal of Psychology*, vol. iii, 1909, pp. 153–157.

As the position of each dot is unknown till it is seen, each stroke has to be aimed. This requires a sustained effort of attention, the degree of effort depending upon the rate of the strokes, and therefore measured by the rate of movement of the dots upon the paper. When marked, the paper furnishes a permanent graphic record of the maintenance of the effort, failure of continuity of attention being indicated by the presence of pencil marks unaimed or of dots unmarked."[15]

Besides the dotting test, devised especially to test the power of sustained attention, Burt used eleven other tests, tests of sensory discrimination, motor ability, memory and association. He also secured estimates of intelligence from the school-masters. It is interesting to note that the dotting test showed the highest correlation with all the other tests, and that it also showed the highest correlation with estimated intelligence. In the preparatory school the correlation between the dotting test and estimated intelligence was as high as eighty-four per cent. The correlation of this test with intelligence appears to decrease with practice on account of the fact that the test becomes more automatic, and consequently makes less demand upon the attention.

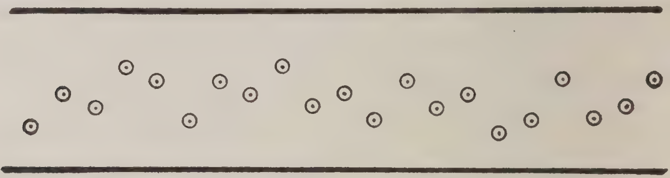

FIG. 9.—Tape used in the dotting test (after Burt, *British Journal of Psychology*, vol. iii, 1909, p. 155)

On the basis of his results with the dotting test and from various other considerations, Burt concludes that voluntary attention, is of all recognized psychological functions, the essential factor in general intelligence.[16] Other experimenters have come to similar decisions. Abelson, from his tests on backward children, deduced that the essential nature of intellectual deficiency was probably a general lowering in the efficiency of performance because of the need of attention.[17] And Dr. and Mrs. Ordahl, who gave a large number of tests to feeble-minded children of the mental ages of six, eight, and ten, were convinced that the fundamental difference between these mental ages is a matter of attention. They conclude that: " In all experiments attention is involved, and it is probable that this is the psychological process in which the levels of intelligence differ." [18]

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[15] *Op. cit.*, p. 154.

This belief in the intimate connection between attention and intelligence, held by recent experimenters, is not a new one. It has been held by a number of distinguished psychologists, such as Wundt, Sollier and Binet.[19] These authorities do not all view the process of attention in the same way, but it is probable that they are all driving at much the same fundamental fact. At present the direct experimental evidence concerning the relation of attention to intelligence is insufficient to justify final pronouncement. What evidence there is, however, coupled with general observation, goes to indicate that attention is as closely related to intelligence as any other known mental function.

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[16] *Op. cit.*, p. 169.

[17] " The Measurement of Mental Ability of Backward Children." *British Journal of Psychology*, vol. iv, 1911, p. 311.

[18] " Qualitative Differences Between Levels of Intelligence in Feeble-Minded Children." *Journal of Psycho-Asthenics, Monograph Supplements*, vol. i, No. 2, 1915, pp. 43 and 49.

[19] See preceding chapter, p. 149.

CHAPTER X

COMPLEX MENTAL PROCESSES

The terms simple and complex must be understood in a relative sense. Even the simplest phenomenon appears complex when viewed in the light of all the relationships into which it enters. It is one of the duties of science, however, to unravel the complexity always present in reality, and, by a process of abstraction which ignores many aspects of the phenomenon under investigation, to pick out those features which appear to be elementary.

By such a process of abstraction, psychologists have distinguished certain processes as elementary. Sensations and perceptions, images and feelings are generally regarded as the simplest and most elementary factors of mind; and the laws of association and attention are the fundamental principles governing the part played by these factors in mental life. The relation of these processes to intelligence has already been discussed. More complex processes remain to be considered. Among the more important of these are reasoning, emotion and will, and to these I shall mainly confine my attention.

Reasoning.—Reasoning is commonly regarded as man's distinguishing mental characteristic. In spite of its preëminent importance, however, its study by experimental psychologists has scarcely more than begun. To attempt an exact definition of reasoning would be beyond the scope of the present treatise. The statement that it is purposive thinking, that it consists in arriving at a mental solution of a problem through a more or less orderly process of association and selection of ideas, must suffice.

The solution of problems is much the same thing as successful behavior, and it is consequently not altogether easy to distinguish between the capacity for reason and intelligence. Problems may be, and often are solved, however, without the aid of reasoning. Animals solve their problems largely by trial and error, without the use of reason. Man does likewise. Some of the greatest problems have been solved by what is called intuition. The solution simply appears. One has an inspiration.

Reasoning at best is elusive and treacherous, so that a man who relies upon it may actually be less successful than one with much less reasoning ability, who acts on impulse. Indeed, as reasoning becomes elaborate it becomes theorizing. A good theory is, of course, an excellent thing, but actions based on theory are commonly distinguished from those based on observation and experience, and the latter are supposed to be successful.

It has often been urged that human beings seldom base their conduct on their reasoning. They act instinctively in accordance with their beliefs, prejudices and wants. They use their reasoning to convince others, and, if necessary, themselves, that the conditions they desire are right, and that their actions are governed by wisdom. A man may act judiciously but not be able to give good reasons for his act, whereas another may act foolishly or recklessly but yet give excellent arguments in justification of his course. On the whole, then, reasoning capacity falls considerably short of being the same thing as intelligence. Problems are solved by means of mental processes other than those of reason; the value of the solutions which occur to one does not depend entirely upon whether they have been reached by a process of reasoning; and even if reason is applied to test the correctness of a solution, its operation is uncertain and erratic; and the utilization of any solution, whether based on reason or not, depends upon mental aptitudes other than reasoning capacity itself. In spite of all this, reason is one of the most valuable of the intellectual processes. Regarded in a broad way, it is dependent upon all the other mental processes.

No very precise tests of reasoning ability have been devised. On the other hand, there are a great many tests in which success depends upon reasoning ability to a very considerable degree. To some extent the teacher tests reasoning ability every time she requires a pupil to solve a problem. Perhaps of all the school problems, those in arithmetic are the best for determining which pupils are the best reasoners. Of course the ability to reason about arithmetical problems alone could not be taken as a measure of anybody's general ability to reason. One may reason well in arithmetic but poorly concerning human nature. It follows that a thorough diagnosis of reasoning ability can be made only on the basis of test problems chosen from many widely different fields.

Aside from test problems involving more or less formal and complete reasoning processes, in all their complexity, there are numerous simpler tests which throw light on the processes which go to make up reasoning. They may be termed tests of logical-mindedness. They include tests of analysis and synthesis, the recognition of absurdities, the ability to define, the ability to interpret a picture,[1] or a stanza of poetry,[2] the ability to form general principles,[3] the ability to distinguish between good and bad reasons,[4] and between sound and false conclusions drawn from stated premises.[5]

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[1] Binet and Simon, "The Intelligence of the Feeble-Minded." Translated by Kite, 1916, pp. 98–99.

[2] Bonser, "The Reasoning Ability of Children," 1910, p. 8.

A number of these tests of logical-mindedness appear in the Binet measuring scale of intelligence, or in its various revisions. Tests of the ability to give definitions occur three times in the Binet and Simon scale. Binet points out there are three kinds of response to the request for a definition. The first is a failure to give a definition. The child remains silent or else responds with some gesture, such as pointing, or with merely a repetition of the word to be defined. The second kind of response is definition by use. Capacity for such definitions is fairly well developed at the mental age of five. At this age the child may be expected to define by use at least four of the following six words: *fork, table, chair, horse, pencil* and *doll.* The third stage is reached at the age of eight or nine, when definitions in terms superior to use are given for at least half of a list of words like the following: *balloon, tiger, football, soldier, automobile, battle-ship, potato, store.* Terman classifies definitions superior to use under three headings: "(*a*) Definitions which describe the object or tell something of its nature; (*b*) definitions which give the substance or the materials or parts composing it; and (*c*) those which tell what class the object belongs to or what relation it bears to other classes of objects."[6] The ability to define abstract terms is tested by one of the eleven-year tests, in which the child is asked, "Can you tell me what 'pity' means? 'Bravery,' 'charity,' 'revenge,' 'justice'?" The test is passed if three of the five words are defined satisfactorily.[7]

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[3] Terman, "The Measurement of Intelligence," pp. 310–313.

[4] Bonser, *op. cit.,* p. 6 .

[5] Kuhlmann, "The Measurement of Mental Development." School Publication, Faribault, Minn., 1917, pp. 82–83.

[6] *Op. cit.,* p. 221.

The inability of children below the mental age of eight to define in terms better than by use is very striking. It is no doubt closely related to the strong tendency of all children below the age of puberty to respond by a verb in the free association test.[8] The commonest child's response to the word *table,* for example, is *eat,* instead of the word *chair*—the favorite adult response; and the commonest child's response to the question, "What is a table?" is that the object is "to eat on."

The following dialogue, reported by Binet,[9] is a good illustration of children's definitions by use. The answers were given by a high grade imbecile, twenty-six years old chronologically and seven mentally.

> Q. What is a house?
> A. A house......well......a house it is to rent.
> Q. A fork?
> A. That is to eat with.
> Q. A mama?
> A. She is to get things ready to eat.
> Q. A table?
> A. It is to eat on.
> Q. A chair?
> A. It is to sit on.
> Q. A horse?
> A. It is to work.
> Q. A snail (edible snail)?
> A. It is to eat.
> Q. A flea?
> A. It is to kill.
> Q. Charity?
> A. It is those who do good in the world.
> Q. Justice?
> A. It is those who do evil.

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[7] Kuhlmann, *op. cit.,* p. 60.

[8] See Woodrow and Lowell, "Children's Association Frequency Tables." *Psychological Monographs,* No. 97, 1916, pp. 78–92.

[9] *Op. cit.,* p. 101.

Q. Goodness?
A. Ah, goodness, it is to get angry.
Q. Virtue?
A. (After thinking a long while) I don't know.

The capacity for analysis and synthesis may be tested by asking the child to point out the way in which things differ and in which they are alike. Here is a test for seven-year intelligence: " What is the difference between: (*a*) A fly and a butterfly? (*b*) Wood and glass? (*c*) A stone and an egg? " The test is passed if the child indicates some real difference in two out of three trials.[10] At a mental age of eight, a child should be able to state in two cases out of four some way in which the following are alike: (*a*) Wood and coal. (*b*) An apple and a peach. (c) Iron and silver. (d) A ship and an automobile.[11]

The recognition of absurdities is given as a ten-year test. It is passed if the child points out the nonsense in three of the following four statements.[12]

(*a*) " A little boy said: ' I have three brothers—Paul, Ernest, and myself! ' "

(*b*) " A bicycle rider, being thrown from his bicycle in an accident, struck his head against a stone and was instantly killed. They took him to the hospital, but they do not think that he will get well again."

(*c*) " A man said: ' I know a road from my house to the city, which is down hill all the way to the city, and down hill all the way back home.' "

(*d*) " Yesterday the police found the body of a young girl cut into eighteen pieces. They believe that she killed herself."

Terman praises the detection of absurdities as one of the most ingenious and serviceable tests of the entire Binet scale. " It is," he says, " little influenced by schooling, and it comes nearer than any other to being a test of that species of mother-wit which we call common sense."[13]

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[10] Kuhlmann, *op. cit.*, p. 36.

[11] Kuhlmann, *op. cit.*, p. 43.

[12] Kuhlmann, *op. cit.*, p. 58.

There are no exact data concerning the relation of the reasoning processes to intelligence. The existing tests are inadequate and lacking in precision, and the investigations are far too fragmentary. We have still to learn the main types of defects; the main factors upon which success depends; the best methods of training and the amount of improvement which they can effect. Only as our knowledge on these and kindred points becomes more specific, will there be much of interest or meaning in the assumption that capacity for reasoning is above all others the distinguishing mark of intelligence.

Defectiveness of reasoning ability in the feeble-minded is striking. On this point, Tredgold takes a decided stand, and the interesting observations of this eminent authority are worth quoting at length.

" I regard the chief characteristic of amentia as a defect of this capacity [reasoning]. This defect reaches its maximum in the most pronounced degree of amentia, and in the majority of idiots the ability to reason is completely absent. The absolute idiots would even die of starvation in the midst of food, if they were not fed. The imbeciles possess some capacity for reasoning, although of a very simple order; whilst in the feeble-minded grade [morons] the defect is still less evident. A feeble-minded child who is ignorant of money values, if offered the choice of a shilling or half-crown, may choose the latter '*because it is bigger.*' Some defect, however, is present in every grade of amentia; and if I were compelled to specify which particular mental abnormality was chiefly responsible for the maladjustment of their conduct, I should certainly say it was the one we are now considering.

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[13] *Op. cit.*, p. 258.

"I know many feeble-minded adults who are regularly employed. They are careful, industrious, and thoroughly trustworthy, but the work they are capable of and the money they can earn is only equivalent to that of a boy or girl of school age, and this for the reason that they have not sufficient intelligence to cope with any situation needing judgment, or do any work which is not of a strictly routine character. Moreover, they find it impossible to lay out the money they earn so as to provide themselves with the necessities of life, and in the absence of some supervision and kindly control they would rapidly come to hopeless want." [14]

Instincts and Emotions.—All of the mental processes we have so far considered are usually termed intellectual. However, it is everywhere recognized that mere intellect is not the only important requisite of successful living. Traits of temperament and character are equally essential. These are very largely matters of will and emotion, and of the interrelationship of these two functions. Both have an instinctive basis. It is indeed true that all mental processes have an instinctive basis, in that all mental processes serve to aid, to develop, or to modify the instinctive or inborn equipment for adjustment to environment. The fundamental aims of life are furnished by our instinctive wants and desires. All incentive to action, if traced back far enough, will be found to take root in instinctive tendencies. Instincts not only furnish us with aims, but in a rough way with the means of accomplishing those aims. But the man at the mercy of his instincts is merely a beast. His aims remain unprecise and unformulated, and his methods of accomplishing them crude and inefficient. I am, consequently, not inclined to regard instincts as identical with intelligence; but that capacity for mental processes which I do regard as intelligence is probably identical with the capacity for that modification of instincts which results in their better adaptation to the varying needs and problems of life.[15]

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[14] "Mental Deficiency," 2d ed., 1916, pp. 116–117.

Conceding that all human activities are at basis instinctive, it is generally recognized that the relationship of instincts to emotions is particularly close. All those natural and unlearned expressions of emotion which lend warmth and interest to human life are little other than instinctive responses. And the relationship of instincts to will is nearly as close as that to emotions. I shall, consequently, at this point consider briefly the relation between degree of intelligence and development of instincts. So little has this latter subject been explored, that we are compelled to rely mainly on one investigation, that by Wylie, on instincts in the feeble-minded.[16]

In general, feeble-minded children show defective development of instincts. Some instincts fail to appear, and the expression of those which are apparent is fragmentary in character, lacking in fullness and vigor. It might be supposed that the instincts not appearing would tend to be those which are the latest to appear in normal children. In general, Wylie's observations tend to confirm this supposition, although there are certain exceptions. Thus, practically all of the feeble-minded, including idiots, showed the instincts of sucking, biting, smiling, and holding up the head, carrying to the mouth, sitting up, standing and walking, and laughing. Half of the idiots, eighty per cent. of the imbeciles, and all of the morons, displayed anger. All three grades play, in various ways, according to intelligence. Idiots play merely by "running around and handling things." Sex instincts, very often in a perverted form, were present in one-third of the idiots, in from fifty to eighty per cent. of the imbeciles, and in all the morons. All other instincts were absent in the idiots. These include: Fear, present in one-half of the imbeciles and of the morons; affection, as evidenced by the desire "to fondle and to be fondled," present in three-fourths the imbeciles and all the morons; shame, present in one-third the imbeciles, and all the morons; and the instincts of imitation, curiosity, acquisitiveness and constructiveness, all found to a greater extent among the morons than among the imbeciles. Only the morons manifested grief, joy and blushing.

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[15] For elaborate discussions, see the symposium on "Instinct and Intelligence," by C. S. Myers, C. Lloyd Morgan, H. Wildon Carr, G. F. Stout and William McDougall, *British Journal of Psychology,* vol. iii, 1910; "The Relation of Instinct and Intelligence," by H. R. Marshall, *British Journal of Psychology,* vol. v, 1912, pp. 247–267; and "Instinct and Intelligence," by N. C. Macnamara, 1915.

[16] "Instincts and Emotions of the Feeble-Minded." *Journal of Psycho-Asthenics,* vol. v, 1901, pp. 98–107.

In spite of the general correspondence between the development of intelligence and of instincts, it would appear that in certain instances considerable discrepancy exists between mental age and what may be termed instinctive age. For example, if we may trust Wylie's observations, a child may belong in the highest grade of the feeble-minded, thus having a mental age of eight or over, and yet show an absence of the fundamental emotion of fear, which in normal children develops during the first few months; and a child may have a mental age of four or five years and be lacking in both fear and anger.

On the other hand, the sex instincts have been noted in idiots who are apparently incapable even of hunger. It is hard to explain these irregularities. Perhaps they may be understood by assuming that fear, except for some primary manifestation that has been overlooked, depends upon a certain degree of intelligence, some ability to comprehend danger, and that the sexual instinct, which we commonly think of as developing only with the age of puberty, as a matter of fact makes its appearance at a very early age, and is dependent upon physiological development merely for certain changes in the form and effectiveness of its manifestations. With these assumptions it may be said that the development of instincts in the feeble-minded, is, like their intelligence, greatly delayed; that on the whole the development of the instincts is closely correlated with that of intelligence, but that in individual cases marked discrepancies may appear between intelligence and instinctive equipment—between mental age and what we may term instinctive age.

In spite of the imperfect development of his instincts, the feeble-minded child is more of an instinctive animal than his normal brother, for his instincts lack the controlling influence exerted by a well-developed intelligence. "His life in many cases may be considered as purely instinctive. It is on account of these instincts that he is oftentimes a menace to himself and to his friends, and it is by reason of them that his condition is earliest recognized, and it is to the expression and repression of them that the chief part of his education must be directed." [17]

In accordance with the general weakness of the instincts in feeble-minded children, we find as the most characteristic emotional character of dull and feeble-minded children an abnormal indifference. The phlegmatic temperament is the most common. This apathetic disposition is particularly characteristic of the lower grades. On the other hand, cases of exaggeration of emotions are not uncommon. An excessive excitability is found in all grades of mental retardation, but is more marked among the higher grades. Contradictory as it may seem, the same child may display both an abnormal lack and an abnormal exaggeration of emotion. He may be lacking in the finer emotions and sentiments, and at the same time suffer an increase in the grosser ones. This condition is indeed quite characteristic of persons of depleted nervous energy. They evidence little capacity for the higher and more cheerful emotions, an inability to be joyous and enthusiastic, and yet at the same time are very irritable and are easily aroused to such emotions as anger and gross sexual love. Mentally retarded children usually appear fairly contented with their lot, and, as often remarked, they commonly manifest a considerable degree of child-like affection.

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[17] Wylie, *op. cit.*, p. 106.

Will.—Emotions and instincts are closely related to will. The will is exerted for aims that are at bottom instinctive or emotional, in spite of the fact that this is usually not recognized by the individual as he acts. At the same time, the greatest obstacles to will are instinctive tendencies which conflict with the reasoned plans that should be carried out. The conquest of disturbing instincts, or of any other distractions, depends largely upon the power of attention, as the latter determines largely to what extent one may stick to one plan or purpose to the exclusion of others. By will, a term used too loosely and variously, I mean very largely effective control exerted by attention and reason over natural instinctive tendencies. I do not use the term to indicate any mental process whatsoever, but merely to indicate the control of conduct by the mental processes. By a strong will, I mean that the actual behavior of an individual accords with the behavior which he anticipates and regards as desirable; that his acts are consistent with his conception of what is wise and right; that resolutions are not facilely broken; and that unreasonable, impulsive or automatic acts are properly inhibited.

Defects of will may be said to be of two sorts, direct and indirect. A direct defect is weakness of will, a lack of persistence, an incapacity to bring about any action that requires much effort. An indirect defect is an exaggerated automatism. The two kinds of defect are frequently associated.

(1) **Persistence.**—If weakness of will is extreme, the result is simply stupor. In milder cases, actions which require any great amount of effort or endurance are avoided. There is a feeling of fatigue and lassitude which seems to prevent the individual from exerting himself. In addition, there is often a certain slowness and unsteadiness of movement, and a general lack of enthusiasm. The accompanying mood varies between indifference and discouragement.

Several tests of will power have been attempted, but necessarily, none are entirely satisfactory. They are mainly tests of the ability to persist in an action in spite of fatigue. One such test, called an achievement capacity test, was used by Fernald, resident physician at the Massachusetts reformatory, as one of a number of tests designed to distinguish the responsible from the irresponsible criminal.[18] Discussing the mental examination of reform school boys, he says: "That function of the mind called will, persistency, determination, pluck or spunk, plays too large a part in the successes or failures of these subjects to be overlooked in an investigation of efficiency. It cannot be measured directly, apparently; but it may be measured in terms of voluntary endurance of discomfort."

The achievement capacity test consists in a measurement of the time that the subject can stand with his heels slightly off the floor. A simple device, consisting of levers attached to the plate on which the subject stands, enables him to tell by observing a pointer in front of him just how nearly his heels come to the ground. Fatigue is rapidly induced, in a natural and harmless manner, and strength of will is measured by the length of time that the subject resists this fatigue and keeps up his heels. The chief disturbing factor is the variation between different subjects in mere physical strength. Fernald believes this factor is unimportant because the test involves those muscles whose strength most nearly corresponds with the body weight, namely, the muscles used to carry and support the body. Hence the person with stronger muscles usually has a greater weight to support.

In practice, says Fernald, the theory of the test has been found valid. "No subject has fallen exhausted muscularly, but every one voluntarily stepped down and walked away, showing that the will to withstand the fatigue longer had yielded before the muscles lost power." The test was given to one hundred reform school boys, and for comparision, to students of the same age in a nearby manual training school. The average time that the heels

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[18] "The Defective Delinquent Class, Differentiating Tests." *American Journal of Insanity,* vol. lxviii, 1912, pp. 538–541.

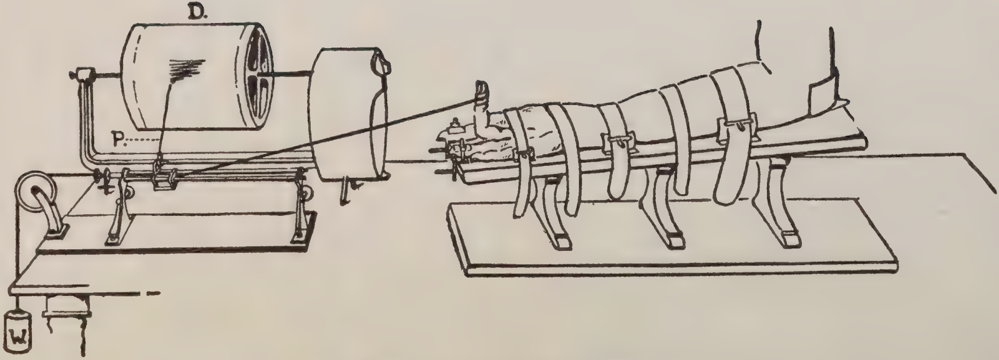


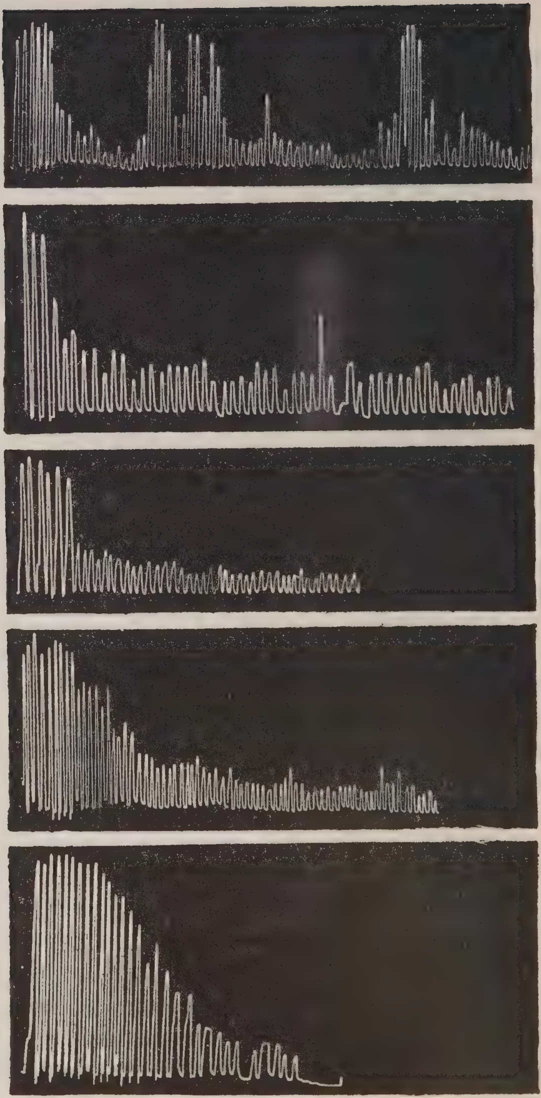
FIG. 10.—ERGOGRAPH TEST.
W., weight. P., pointer. D., rotating drum.

were kept raised was three times as great for the normal group as for the reformatory group, being fifty-two seconds for the former and only seventeen for the latter. Whatever the shortcomings in the test, the results are certainly interesting.

An older and better known test of the ability to persist in an effort in spite of fatigue is the ergograph test. By means of somewhat elaborate apparatus, the test measures the ability to continue to raise a heavy weight once every second with the middle finger. The other fingers, as well as the whole forearm, are firmly clamped in a support. The weight is attached to the finger by a cord which moves over a pulley, as shown in the accompanying diagram (Fig. 10). A pointer, attached to the cord, scratches on the smoked paper of a rotating drum, thus producing a record of the movements of the finger in the form of ergograph curves, some of which are here reproduced.

I have found the study of these ergograph curves, and of the children making them, so fascinating that I have spent many days in obtaining such curves from children in the lower grades and in special classes for the mentally retarded. Of the large number of curves obtained, the few here reproduced (Fig. 11) have been selected as typical. It should be stated that the form of curve obtained depends upon numerous conditions—the heaviness of the weight to be lifted, the strength of the muscles, the length of time since the preceding trial, and so forth. The curves here presented have been selected with great care, so that they should be strictly comparable.

The mental age (*M.A.*) and chronological age (*C.A.*) of each child is recorded opposite his curve, so that few explanations are necessary. The thing most typical of



No. 1.
C. A., 9.5 yrs.
M. A., 7.3 "

No. 2.
C. A., 10.0 yrs.
M. A., 7.0 "

No. 3.
C. A., 7.0 yrs.
M. A., 7.0 "

No. 4.
C. A., 9.5 yrs.
M. A., 9.3 "

No. 5.
C. A., 16.0 yrs.
M. A., 10.5 "

FIG. 11.—Children's Ergograph Curves.

children of low mental age, normal or feeble-minded, is that they give up after a few fairly vigorous contractions. The effort required, of course, increases very rapidly, but adults and older children, with stronger will, do not quit suddenly as soon as the effort becomes considerable; they go on, doing the best they can, so that through a considerable time the curve made by the top of the record declines but gradually. Children of the mental ages of six to eight, however, give as a typical curve one which drops off with extreme suddenness after a few good contractions. This characteristic cessation of effort is well shown in curves Nos. 1–3. The height of the first contractions of the curves depends mainly on the size of the fingers and so is correlated more with chronological and physiological age than with mental age. It is the form of the curve, rather than its height, which is significant; and all three of the specified curves, made by children of mental age seven, show the same sudden drop.

That this characteristic drop in the curve is due to a cessation of effort, and not to muscular exhaustion, is proven not only by its suddenness, but in many cases by the equally sudden reappearance of good contractions. Curve No. 1 represents such a case. After the finger is apparently so exhausted that it can scarcely move, it suddenly begins to contract as well as it did at the start. The contractions again suddenly cease only to rise once more. Curves showing this vacillation of will are not at all uncommon. They prove that the child is merely making spasmodic efforts and is incapable of persistence to the end. He runs no risk of exhausting himself. He is like most morons. They cannot be fatigued because they will not work long enough.

Curve No. 4 shows an intermediate stage. While the little girl who made this curve had the same chronological age as the mentally retarded boy who made the typical curve No. 1, she was two years ahead of him in mental age. Her curve shows not only somewhat greater strength but decidedly more perseverance. Curve No. 5 is given mainly to show contrast. It closely resembles the normal adult curve. The rapidly sloping part is more nearly convex, instead of extremely concave as in the case of the mental sevens. The cessation of effort is more gradual. It was made by a moron girl ten and a half years old mentally and sixteen chronologically.

(2) **Suggestibility and Impulse.**—The ergograph curves furnish a good demonstration of the lack of sustained effort, and of the resulting inactivity and feeble accomplishment which are the primary symptoms of a weak will. These symptoms, however, are seldom the only ones. As the exertion of control weakens, various mechanisms begin to assert themselves on their own account, and we have appearing a large variety of more or less abnormal phenomena. These constitute what we may call the indirect symptoms, symptoms which some psychologists group under the designation of automatisms, and which, for the most part, are matters of increased suggestibility or exaggerated impulsiveness.

As a rule the feeble-minded at any age, like young, normal children, are credulous and readily suggestible. This, together with their weakness of intellect, makes them the easy prey of vicious and evil characters. Various interesting methods have been devised for testing suggestibility. One of these is a line-copying test. The subject is shown one at a time a series of lines printed on cards. The first three form a series of regularly increasing lengths. The remainder all have the same length as the third line. The subject is asked merely to reproduce the length of each line by drawing it on paper. The marked and regular increase in length of the first three lines serves as a suggestion that the increase will continue throughout the series, so that the subject may continue to increase the length of his copies long after the increase in length of the lines presented to him has stopped. The results sometimes obtained are almost incredible. Some children act as though they had completely forgotten what they were originally told to do, and lapse into a state of mind where each line is merely a signal to draw one a little longer than the previous one. An interesting illustration is that reproduced in figure No. 12, showing the performance of a highly suggestible moron girl.

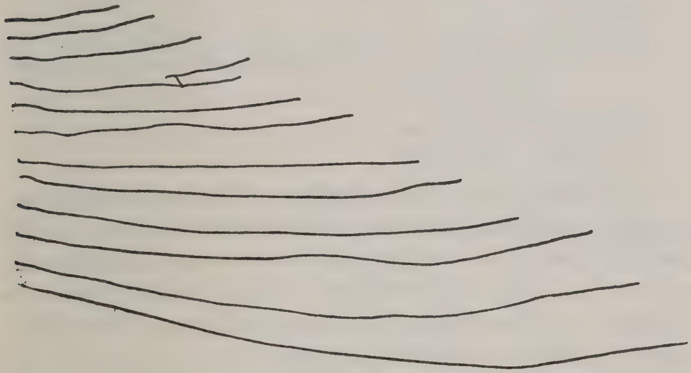


FIG. 12.—Showing performance in suggestion test. The standard lines, from the third on, remained the same in length.

Binet describes a number of other interesting and highly amusing tests of suggestibility, adapted to early mental ages. One of these is assent without motive to an obscure affirmation or simply to the exclamation, "Isn't that so?" The child of seven or eight may promptly reply in the affirmative, as though assenting to the statement of an important fact. At later ages, toward puberty, the child remains unmoved, or betrays astonishment and asks, "What do you mean?" Binet also gives a test of a much bolder sort:

> "We rise, we take a chair and show it to the imbecile.
> Q. What is that?
> A. A chair.
> Q. Serious mistake! It is not a chair, it is a cork-screw. (A pause.) Let us see, what is this? (and we present again the chair).
> A. A cork-screw.
> Q. Upon what are you sitting?
> A. Upon—a cork-screw.

"This test succeeds invariably with all our imbeciles, even the most rebellious; and one can believe that it would require a very low mentality to thus consent to change the name of a very familiar object. It is evident that in a company of friends one who attempted to try this experiment would have very little success." [19]

It should of course not be inferred that, in the preceding experiment, the imbecile was led to perceive the chair as a cork-screw or to believe that it was a cork-screw. He was merely led to act as though he did. Consequently this test, as other suggestion tests, merely makes trial of docility. Docility of this sort, however, as Binet insists, is a form of suggestibility. "There are," he writes, "two forms of suggestibility which have not been sufficiently differentiated: the suggestion of hallucinations, of ideas, of concepts on the one hand, and the suggestion of acts, of words, mimicry on the other. Docility is a suggestibility which shows itself simply in acts, words, attitudes. . . . It is not the reason of the agent which bends, it is his will, his character. One may have suggestibility of character without having suggestibility of reason."[20]

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[19] Binet and Simon, "The Intelligence of the Feeble-Minded." Translation by Kite, 1916, p. 109.

An exaggerated automatism may show itself in impulsiveness as well as in suggestibility. Impulsiveness may be of either of two widely different types: the emotional, and the unemotional or mechanical. In the emotional type, the individual shows signs of driving power, but the power is not under control. The impulses may not be particularly strong, but they sway the conduct of the individual because of the weakened power of inhibition. In the mechanical type, we see simply the effects of the activity of an unenergetic nervous system, functioning according to whatever habits the individual has happened to acquire, with a total absence of attentive reflection or of any reasoned purpose.

Of the emotional types of impulsiveness, violent displays of temper are among the most common. Quarrelling and fighting and generally disorderly conduct, sometimes criminal in nature, may be the result. In other cases, there is inability to inhibit immoral impulses. It is said that every feeble-minded girl is a potential prostitute. The sexual impulses may not be as strong as in the normal individual, but on account of the weakened will and heightened suggestibility they control the course of conduct. Again, the individual may be a victim of peculiar antisocial impulses. These morbid impulses display great variety. Some are exceedingly serious; a recurrent tendency to steal, for instance, to set things on fire, to destroy property or to mutilate or kill animals or human beings.

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[20] *Op. cit.*, p. 119.

In the unemotional type of impulsiveness, the automatism consists in acts, often of a silly nature, repeatedly executed in a purely mechanical fashion. Children may constantly echo the movements or words of another. Biting the nails, drumming on the desk with the fingers, or muttering some phrase over and over again, are exceedingly common habits in all grades of children. Certain stereotyped performances may be persisted in day after day, and year after year. The majority of imbeciles whom I have observed show these peculiar habits. One such, whose duty it was to shove all day long a floor polisher along the hall in front of a room which I occupied one summer, had the habit, when no one was watching (so far as he knew) of taking one step forward and then one step backward, in a more or less swinging or dancing style. He continued, during this performance, to hold the handle of his floor polisher, but in such a way that the polisher itself remained stationary. I can testify that these movements were repeated without interruption for over an hour, and I suspect that as a regular thing fully one-half of this imbecile's working day was devoted to these strange exercises.

CHAPTER XI

MENTAL ORGANIZATION

The Problem of the Interrelationship of Mental Traits.—The brightness of a child does not depend upon his ability in any one respect. A child is by no means of superior intelligence simply because he can draw well, or because he is good at rolling a hoop or playing marbles, or even because he can learn his multiplication table with exceptionally little study. As repeatedly pointed out, intelligence is the capacity for success in performances in general. It includes all the capacities for the hundreds and thousands of different things which a human being can do. As soon as this is admitted, the question at once arises: Are all these hundreds and thousands of capacities separate? Do they vary so independently of each other, that the degree of perfection of one is in no way an index to the degree of perfection of the others?

I know of no writer so extreme as to insist that there is utter lack of relationship between the different performances of which a human being is capable. It is true that Thorndike, one of the world's most eminent educational psychologists, has been accused of taking this stand. Binet writes that according to Thorndike, the mind is a vast multitude of absolutely unlike faculties, existing side by side, but remaining rigorously independent.[1] Binet's citation, however, somewhat exaggerates Thorndike's views. A more just conception of his position is given by the following quotation: " Almost any, if not any, one thing in the mind may happen in partial independence of almost any, if not any, other thing."[2] However, it can hardly be denied that Thorndike at times approaches something very near an atomistic theory of mind, a theory, that is, that mind is merely a collection of a vast number of extremely minute functions, each of which is complete in itself, although united to others by more or less mysterious "bonds." As atoms, he uses a miscellaneous assortment of feelings, acts, "connections," "capacities" and "abilities." This opinion considers mind to be merely an agglomeration or "sum total" of "an individual's feelings and acts, of the connections between outside events and his responses thereto, and of the possibilities of having such feelings, acts, and connections."[3] He holds that "the mind is a host of highly particularized and independent abilities;"[4] and emphasizes the independence of these innumerable mental processes. Even so, Thorndike is far from believing that there is no relationship or interdependence between the innumerable specific mental acts. Indeed, all authors have admitted some sort of interrelationship of mental processes, some degree of mental organization or unity of mind; and it is the problem of the present chapter to discuss the nature of this organization.

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[1] "Les idées modernes sur les enfants," 1909, p. 242.

Three Psychological Theories of Mental Organization.—The problem has had a long and devious history which is worth briefly reviewing. Early psychology assumed that mental processes were largely manifestations of the activities of the soul. Starting with the distinction made by Aristotle between the "rational" soul and the "animal" soul, philosophers finally arrived at the classical triple distinction of the three faculties of knowing, feeling, and willing.[5] Each of these was a manner of performing, a mode of activity, possessed by the soul. Whenever one experienced an emotion, his soul was exerting its faculty for feeling, and whenever one perceived anything, its faculty for knowledge, sometimes called the faculty of cognition or intellect. Of course all such explanations of mental processes as faculties of the soul were unsound and futile. Very largely, however, they seem to have been intended to describe the mind, to state the different kinds of things the mind does. The three great faculties of knowing, feeling and willing were soon subdivided into many subordinate ones, until finally the number of subfaculties was quite large.

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[2] "Educational Psychology," 1903, p. 28.

[3] *Op. cit.*, 1910, p. 188.

[4] *Op. cit.*, 1903, p. 39.

The classical doctrine of the three faculties meant simply this: First, that every mental act could be classified under one of these three headings—intellect, feeling, and will; second, that all the acts included under any one of these headings were due to the activity of a single factor. Thus every act of perceiving or judging was to some extent due to the functioning of one faculty or capacity. The ancient view of this faculty as a capacity of the soul has no significance; the fundamental thought is little modified if we substitute *brain* for *soul;* because the crucial idea is merely that all similar mental acts derive their characteristics in part, though not entirely, from a single, unitary factor, from one condition or set of conditions. Thus stated, the faculty psychology contains a germ of truth; that is why it has been " so easy to scotch, but hard to kill."

After a long and flourishing existence, the faculty psychology finally fell into disrepute. Curiously enough, the really serious arguments against it are of two quite opposite sorts and both are tenable. On the one hand, faculty psychology is said to be at fault because it divides the mental life into isolated compartments independent of each other, whereas in reality the mental life is unitary. Man is one, not three. " We do not think and only think in one moment, and will in another, and feel in yet another. There is no experience which is now intellective, now volitional—and at another moment, affective. The unitary experience may not be broken up thus. Any portion of concrete experience, select it by what rule we may, is a thinking—feeling—willing experience."[6]

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[5] See Dessoir, "Geschichte der neuere deutschen Psychologie." vol. i, pp. 196–381.

The other objection to the faculty theory, made by men, who, like Thorndike, emphasize the relative independence of each specific mental act, is that no such thing as a faculty exists, because each act differs from all the others, even when it may be classified under the same heading. It is pointed out that a person may have a good memory for faces with a bad one for names; that he may listen attentively to an orchestral symphony and dream through a lecture on mathematics; that he may reason well in one line of business and poorly in another. There is no faculty of memory as such, these authors say, because one thing may be remembered while another is forgotten. " There is no one memory," writes Thorndike, " to hold in a uniformly tight or loose grip all the experiences of the past. There are only the particular connections between particular mental events and others, sometimes resulting in great surety of revival, sometimes in little."[7]

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[6] Fletcher, "Introduction to Philosophy." 1913, p. 209.

[7] "Educational Psychology," 1910, p. 188.

Here, then, are three distinct psychological theories. The oldest and perhaps the most influential is the doctrine of faculties, the doctrine that certain mental processes are alike in some important respect, and influenced, determined in character, to some extent, by a single factor. Also, there is the doctrine of unity of mental life, which may be carried to the point of excluding any possibility of separate faculties. The third view, extensively advocated at present, is that each mental process is so emphatically unrelated to any other that to regard any large group of mental processes as being controlled by the same factor is misleading. This doctrine contends for mental *disorganization,* and according to it the degree of interrelationship between mental processes of the same class is not sufficient to justify any grouping of them together as dependent upon a single capacity.

Corresponding Theories of Brain Action.—Each of the three psychological theories of mental organization has its parallel theory of brain action. The doctrine of faculties, in an exaggerated form, found its counterpart in the theories of phrenologists. The phrenologists busied themselves with finding the brain " seats " of the faculties recognized by the psychologists, just as two centuries before a great French philosopher had found a seat for the soul, in a little protuberance of the brain known as the pineal gland, between the cerebral hemispheres. Gall, the famous founder of phrenology, did not believe in the possibility of locating the soul itself, but he thought he could discover the seat of its various faculties. Of these faculties or aptitudes he recognized no less than twenty-seven. He held that each one was dependent upon the activity of a particular area of the cortex, and further, that the development of each area of the cortex could be judged from the external shape of the skull.[8]

Phrenology has never met with scientific sanction. It very soon gave way to a theory which held that the brain functioned as a whole in the case of each specific mental act, and asserted, on the basis of numerous experiments in which portions of the brains of animals were removed, that there was no special seat for each of the mental functions. One part of the brain did not function in smelling, another in seeing, and yet another in willing; but the same parts, in fact, all parts, could in succession do all of these things. Removal of one part of the brain, it was claimed, instead of bringing about the loss of one particular ability or faculty, resulted in a general impairment of all mental functions. This doctrine that the whole brain was a single unitary organ of intelligence may be regarded as the physiological equivalent of the psychological theory of the unity of mind.

The theory, however, that all parts of the brain had the same function finally gave way before the results of remarkable experiments performed during the latter part of the nineteenth century. These experiments called forth a doctrine of the specialization in function by different parts of the brain, known as the doctrine of cortical localization. Localization of a particular mental process in any part of the brain means simply that the part in question must be active whenever that mental process occurs. It does not mean that other parts of the brain never coöperate with the centre in which a given function is said to be localized. Thus, to say that vision has its seat in the extreme rear of the cerebral cortex, in the occipital lobes, means no more than that whenever one sees, the brain cells in this region are active.

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[8] "L'anatomie et la physiologie du système nerveux; en général et du cerveau en particulier, avec des observations sur la possibilité de reconnaître plusiers dispositions intellectuelles et morales de l'homme et des animaux par la configuration de leur tête," 4 vols., Paris, 1810–1818.

Investigation has now localized all the senses in some part of the cortex. For example, the centre for vision has been discovered in the rearmost part of the cortex, in the occipital lobes, through experiments by Munk and others, which proved that removal of both occipital lobes in the monkey causes complete blindness. Hearing has been definitely localized in the temporal lobes of the cortex, lying just within the temple, and the cutaneous and muscular senses, which give sensations from the skin and muscles, in a long convolution extending along the side of the brain. It has been found, moreover, that certain regions, situated just in front of the cortical seat of cutaneous and muscular senses, could be stimulated by electricity, so that particular muscles contracted. These regions have been named the "motor area." They are composed of the brain cells connected through nerves with the muscles; whereas the sensory areas—the seats of the various senses—are made up of the brain cells connected with the sense organs through sensory nerves. The sensory areas receive nervous currents from the sense organs, while the motor areas send nervous currents out to the muscles. In man, the sensory and motor areas do not include more than about one-third of the whole cortex. The general function of the remaining two-thirds is the coördination of incoming currents with outgoing ones. Such a statement of function is decidedly vague, of course, serving to do little other than conceal ignorance.

The localization of sensory and motor areas in the cortex has been unquestionably established, an accomplishment that ranks high in modern science. Its implications, however, have frequently been exaggerated. Some writers have taken it to mean that each different mental process—a sensation, a memory, a judgment, or what not—involves exclusively a particular set of nerve cells. This misinterpretation renders the theory of cortical localization a counterpart of psychological atomism.

The Evidence from Correlations.—A brief account has now been given of three widely divergent views of the mind's mechanism. The first considers mind to be a combination of faculties, or manifestations of faculties; the second regards it as a homogeneous unit, or the manifestation of a unitary soul; the third believes it to be a mosaic of innumerable elementary processes. The first is the multifocal theory; the second, the unifocal; and the third, the non-focal. Each has its counterpart in a theory of brain action.

For the purpose of judging between the three, psychologists have carefully examined the correlations between different mental traits. Because each theory implies different relationships between mental traits, the determination of these relationships should establish one of the three as correct. The rapid multiplication of mental tests during recent years has been of great service in this connection. These tests measure innumerable traits. Just what relationship between the measurements of these traits is implied by each of the three views of mental organization?

According to the multifocal theory, mental tests of the same general function or faculty should correlate more closely than tests of different faculties. Thus several different memory tests given to a large group of children should correspond more closely with each other than should a memory test with a test of sensory discrimination, reasoning, or attention.

According to the second theory, the unifocal, the correlation between different tests is due entirely to some single general factor. Extreme versions of this theory require the correlations between all mental tests to be perfect. Since all mental traits are but manifestations of the working of a unitary mind, according to the unifocal theory, if one child's mind is better than that of another in any specific trait, it should be correspondingly better in every other.

According to the third theory, the non-focal, no correlation at all should appear between any two tests except in so far as they involve identical elements. The fact that one child has a better memory for spoken numbers than another, would not, under this theory, indicate that he has also a better memory for printed numbers. There should, moreover, be no greater correlation between two different memory tests than between a memory test and a test of attention, because in all cases the correlation should be practically zero, if, as the non-focal theory states, all mental traits are unrelated. The different theories of the mind's constitution thus imply different degrees of correspondence or correlation between the various mental traits; consequently, it is by the study of correlations that they must be compared.

The correlations first obtained seemed to support the non-focal theory. They were so low in most cases as to suggest little or no correspondence between any two mental abilities. Thus, Wissler, who published the results of the tests given for many years to the freshmen of Columbia University, came to the conclusion that although the markings of students in college classes correlate with each other to a considerable degree, they do not bear out the mental tests, nor do the mental tests show much correlation with each other.[9]

To a considerable extent the correlations found at first were low because of inaccurate measurements and inadequate statistical methods.[10] Even from the first, however, the correlations obtained were far from being as low as the non-focal theory demanded. With improvement in tests, in the manner of giving them and in the statistical methods of calculating the correlations, it has gradually become established that even quite dissimilar tests may show a very decided correlation. With a large group of individuals, *some* degree of correspondence appears between their rankings in one test and in most other tests. Plainly, mental abilities are related. At the same time, no two tests give results that correspond perfectly; so that while mental abilities are related, they are partially independent.

This state of affairs evidently cannot be satisfactorily explained by any one of the three theories of mental organization under discussion. Some more flexible theory is evidently required, which will take into account the complexity of the conditions determining any particular mental ability. Such a theory has recently been proposed by Spearman, and is now widely known under the name of the two-factor theory. It is immensely important, and must consequently be examined in detail. Certain modifications may then be suggested, which seem necessary to adapt the doctrine to all the facts bearing upon it.

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[9] Wissler, "The Correlation of Mental and Physical Tests." *Psychological Review, Monograph Supplements*, vol. iii, No. 6, 1901.

[10] See Spearman, "'General Intelligence' Objectively Determined and Measured." *American Journal of Psychology*, vol. xv, pp. 222-225.

Spearman's Two-Factor Theory.—Spearman's theory amounts to a combination of the non-focal and unifocal theories, conceding, in a way, the truth of both. On the other hand, Spearman finds no validity whatever in the multifocal theory. His opinion is "that a person's success in any intellectual performance may be regarded as the joint product of two factors."

"The one is 'specific ability' for the performance in question, with all its particular features. The second is 'general ability.'" "While the range of the specific factor is exceedingly narrow, that of the general factor is universal; and between these two there appears to be no intermediate."[11]

It should be observed that Spearman's theory is not a theory of the functions of the soul, but simply a statement concerning the conditions which determine the nature, and more especially the efficiency, of any mental act. It considers that these conditions manifest two degrees of generality. In the first place, there are certain conditions that have to do with the efficiency of one mental act but of no other. These are specific abilities. In addition, however, there is a general factor, which influences the efficiency of all mental acts. This is general ability. Neither specific ability nor general ability are mental processes; they are conditions of mental processes, that is, factors determining the efficiency of mental processes. The success of a mental act never depends upon either specific or general ability alone, but always upon both.

Spearman applies to mental phenomena a principle that is indubitably applicable to physical phenomena. For example, let us consider the strength of the thumb and of the thigh. Each is influenced by factors that cannot affect the other, such as the development of specific muscles. The muscles of the thumb may be impaired without injury to those of the thigh. At the same time the strength of both is influenced by a more general factor, one affecting the strength not only of these two parts of the body but of all regions—the condition of the blood. A man may have a strong thumb and at the same time be weak in the legs, but his strength in both regions must suffer from a fever.

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[11] Hart and Spearman, "Mental Tests of Dementia." *Journal of Abnormal Psychology*, vol. iv, 1914, pp. 219–221.

It is immediately apparent that all events and their characteristics are caused by conditions of varying extent and influence. The price of potatoes is affected by specific factors, which have no effect upon prices of wheat or beans; but more general factors, such as war, join these specific factors in determining the price of potatoes and other commodities as well. The price of potatoes is not determined solely by war, the general factor, nor by the success with which potato bugs are exterminated, a specific factor. It is determined by a union of these factors and others, acting simultaneously.

Spearman's theory merely insists upon the *existence* of both general and specific factors; it does not explore the exact nature of these factors. Nevertheless he offers suggestions in detail, in order to clarify his theory. Of specific abilities in the case of mental performances, he gives the following illustration:

" Suppose," he says, " that a schoolboy has surpassed his fellows in the observation of birds' nests. His victory has, no doubt, depended in part on his capacity for the general form of mental activity known as ' observation.' But it has also depended on his being able to apply this form of activity to the matter of birds' nests; had the question been of tarts in the pastry cook's window, the laurels might well have fallen to another boy. A further influence must have been exercised by the accompanying circumstances: to spy out nests as they lie concealed in foliage is not the same thing as to make observations concerning them in the open light of a natural history museum. Again, to discover nests at leisure is different from doing so under the severe speed limits prescribed by the risk of an interrupting gamekeeper. The boy's rank may even depend largely on the manner of estimating merit; marks may be given either for the gross number or for the rarity of the nests observed; and he who most infallibly notes the obvious construction of the house-sparrow may not be the best at detecting the elusive hole of the kingfisher. Every one of these features of the observation, then—and their number might be indefinitely extended—must be considered as capable of influencing the success of our hypothetical boy; one and all constitute elements of the 'specific ability' concerned. Any performance may have a large or small proportion of such elements in common with another performance; in other words, the specific ability for the one may have much or little overlapping with that for the other." [12]

When specific elements so overlap that two performances are almost identical, " a person's success in one of them must give probability of success in the other also, and the two performances must become highly correlated with one another." When, however, two performances are so different that there is little or no overlapping of specific abilities, the correlation between them is due entirely to the general factor, a factor which influences all performances.

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[12] Hart and Spearman, *op. cit.*, pp. 219–220.

Although he is certain that a general mental factor exists, Spearman is doubtful of its exact nature. He refers to it as a common fund of intellective energy, and considers it closely connected with the capacity for vivid awareness or attention. Whatever the nature of the general factor, it contrasts sharply with mechanical habit. The highest correlations with intelligence are produced by performances requiring the most attention.[13] It is true that in the case of morons, the most mechanical tests, such as mere rate of tapping, show well-nigh as much correlation as the more intellectual—as the interpretation of pictures for instance.[14] Spearman explains this by the fact that at a level of ability as low as that of mentally defective children, not even the simplest tasks are thoroughly enough mastered to become mechanical.

Having observed that mental ability is a matter of attention rather than of mere mechanical skill, Spearman proceeds to point out that one of the most remarkable differences between an attentive activity and a purely mechanical activity is that the latter does not interfere with simultaneous activities. More than one non-mechanized activity, on the contrary, cannot be carried on at once with success. One's first efforts to ride a bicycle require attention, and consequently they occupy the mind fully; in time, however, the performance becomes practically mechanical, so that the rider is able to look freely about him, to ponder over problems, or to light a cigarette. Now, if the attentive activities are thus distinguished from the mechanical by acute competition with one another, plainly they are competing for something; if the perfection of a non-mechanized activity can occur only at the expense of all other activities, the conclusion is unavoidable that all these manifestations of energy are derived—to some extent, at least—from a general fund. Thus Spearman concludes that his general factor may very well be the general fund of brain energy possessed by the individual.

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[13] Burt, *British Journal of Psychology,* 1909, p. 167.

[14] Abelson, *British Journal of Psychology,* 1911, p. 300.

The two-factor theory, although primarily psychological, has, like other theories of mental organization, its physiological counterpart. The specific elements of mentality may be identified with the efficiency of particular cortical regions or particular chains of nerve cells, whereas the general factor corresponds to the efficiency of the entire cortex. Spearman, with the great majority of contemporary psychologists and physiologists, believes it to be well established that "each momentary focus of cortical activity receives continual support from energy liberated by the entire cortex."

The matter is put very clearly by Pillsbury, in a recent textbook: "When we speak of the action of a single group of cells," he writes, "it is probable that the group is merely the centre of excitation in a very wide region. The excitation that arouses that group spreads to very remote parts of the brain. Action is always of large masses of nerve-cells, but of the mass, certain portions are emphasized, the others acting in very much slighter degree. There is a complicated interplay of part and part throughout a very large portion of the mass of neurones, although only a relatively few are in great activity. . . . Each contributes its share to the total action, although one alone stands out prominently." [15]

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[15] "Essentials of Psychology," 1916, p. 43.

I was similarly convinced concerning the functioning of the cortex by experiments showing the speed with which a person can move his fingers in response to the cessation of a light or a sound. "The explanation of the experimental data," it was stated, "seems to require us to regard the central nervous system as not merely a network of paths, but also as the seat of a complex system of interrelated activities and potential energies *which is disturbed throughout* by any change in any part of the system."[16] "There is energy, the intimate nature of which we must admit is as yet unknown, present in the central nervous system. It is probable that this energy is of an electrical nature, and that it involves many, if not all, of the neurones of the central nervous system. The condition within any one neurone is to be thought of as interrelated with the condition of all the others, so that there is always involved an immensely complicated and widespread system of energies, including, perhaps, both potential chemical energies and electrical activities."[17]

A disturbance occurring at any one point in the cortical system of energies brings about a readjustment of the whole, which readjustment may release energy on the motor side and produce bodily movement. Every mental operation, then, as Spearman points out, requires two things: "First, a specific activity of a particular system of neural structures; and, secondly, the concurrence of neural energy from the whole, or a large part, of the cortex."[18]

The present work does not permit discussion of all the proofs presented by Spearman in support of his theory. Certainly they are impressive. In spite of the fact that his theory is still on trial,[19] it probably comes closer to the truth than any theory of mental organization proposed to date. Its particular merit is its emphasis upon the existence of general ability.

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[16] Woodrow, "Reactions to the Cessation of Stimuli and Their Nervous Mechanism." *Psychological Review,* vol. xxii, 1915, p. 451.

[17] *Op. cit.,* p. 446.

[18] Hart and Spearman, *op. cit.,* p. 72.

Spearman hesitates to identify this general ability with general intelligence, but in all likelihood his theory will eventually narrow to a theory of intelligence, a theory, that is, applying only to performances that are correlated with intelligence.[20]

A Multifactor Theory.—Notwithstanding its great value, Spearman's two-factor theory is undeniably in need of one fundamental alteration, as well as minor modifications. As I have said, it combines elements of the non-focal and unifocal theories, holding the conditions which determine the efficiency of any mental act to be always one of two degrees of generality—either very specific or very general. Now it is probably much nearer the truth to say that efficiency is determined by conditions of all degrees of generality than to limit these conditions to two degrees of generality. At any rate, the evidence at hand clearly shows that there are conditions intermediate in generality between the very specific and the very general.

Does not an accurate view of the constitution of intelligence, then, combine all three theories of mental organization, the unifocal, the multifocal and the non-focal? Such a theory regards the conditions of success in any act of intelligence as being of at least three degrees of generality, namely, very general, quasi-general and very specific.

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[19] See McCall, "Correlation of Some Psychological and Educational Measurements." *Teachers College, Columbia University, Contributions to Education.* No. 79, 1916, pp. 56–59. Also King, "The Relationship of Abilities in Certain Mental Tests to Ability, as Estimated by Teachers." *School and Society* vol. v, 1917, p. 209.

[20] On negative correlations, see Chapter VIII, pp. 157-165.

Just what the intermediate faculties are is a problem whose experimental solution has only begun. Recent work indicates the existence of a general memory ability.[20] Although not certain that the general capacity for attention is different from Spearman's general factor, I believe that I have demonstrated that there is a general capacity for attention.[21] There is evidence also of a general capacity for imagination.[22] Thorndike, contradicting his earlier views, now refers to the mental "levels" of sensitivity, association and analysis.[23] By "levels" he means exactly what others mean by general capacities or faculties, namely, that two tests of the same function or level will correlate more closely than two tests of different mental functions or levels.

To speak of a general memory ability, or faculty of memory, does not mean of course that this general ability is the only condition of successful remembering. There are in addition specific conditions which vary in the case of each different thing to be remembered, as well as the general intelligence factor. Thus a good memory for faces may accompany a bad one for names. Each act of memory involves certain factors which *partially* differentiate it from every other. Nevertheless, different memory tests correlate with each other more than tests chosen at random. Consequently it is correct to speak of a person's general memory ability. His memory may in general be good, although for some things it is much better than for others.

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[21] Carey, "Factors in the Mental Processes of School Children," part ii, "On the Nature of the Specific Mental Factors." *British Journal of Psychology,* vol. viii, 1915, p. 80.

[22] "The Faculty of Attention." *Journal of Experimental Psychology,* vol. i, 1916, pp. 285–318.

[23] Heymans and Brugmans, "Intelligenzprüfungen mit Studierenden." *Zeitschrift für angewandte Psychologie,* vol. vii, 1913, pp. 317–331.

[24] "Educational Psychology," revised edition, 1910, pp. 190–191.

The theory at which we finally arrive, then, as the only one suited to all the facts, may be termed a *multifactor theory,* contending that the factors determining the nature of any mental event, like those determining any other event, belong to many different degrees of generality. The cause of anything is the sum total of the conditions producing it; and these conditions always show an indefinite number of degrees of generality. For practical purposes of the psychology of intelligence, the factors determining the efficiency of any particular performance may be classified, no doubt, under one of the three headings: specific, general and quasi-general. Factors of at least these three degrees of generality always coöperate. Our multifactor theory, then, at once combines the three old theories—the non-focal, the unifocal and the multifocal—and endows each with a more elastic utility.

CHAPTER XII

HEREDITY

Definition of Heredity and Environment.—All circumstances which determine what a human being is, or what he shall become, may be grouped under two headings: environment and heredity. Every child originates in the union of two germinal cells, the ovum of the female and the spermatozoon of the male; consequently, all that he ever becomes depends upon the original nature of these two cells or else upon the influences which act upon them. Any trait that is due to the nature of the germinal cells is the result of heredity; while any trait due to influences acting upon these cells as they develop into a man or woman is caused by environment.

An individual need not resemble either of his parents with respect to a given trait in order that we may consider that trait inherited. For example, a child may owe the color of his blue eyes to heredity, and have brown-eyed parents. But the trait in question must be due to the nature of the germ cells contributed by the parents. Similarly, any trait which is lacking because of the absence of something in the germ cells, and not because of any defect in the environment, is lacking because of heredity.

It is true that the presence of any trait is never entirely caused by either heredity or environment, but always by both. *Some* environment, at least favorable enough to maintain life, must always exist. The necessity of a suitable environment is especially evident in the case of mental traits, since few, if any, mental traits are present even at that relatively advanced stage of development marked by birth. But the nervous system is present at birth, and the nature of mental traits that later develop depends upon the nature and development of the nervous system. The nervous system in turn depends upon the original germ plasm as well as upon the action of environmental factors. Thus, indirectly, mental traits may be due to heredity, and it is quite conceivable that they are determined by heredity to the same extent as are many physical traits.

In view of the intimate relation between heredity and environment, it seems at first impossible to determine whether the cause of any mental ability or disability lies in heredity or in environment. It has been established, however, in many cases, that certain mental defects could not have been avoided under any environmental conditions, and that certain mental abilities would have been manifest in any ordinary or "normal" environment.

The meaning of "normal environment" must be kept in mind throughout a discussion of the inheritance of mental traits. A normal environment signifies any that will allow an innate tendency to develop. For example, a child may be formed from the union of germ cells of such nature that, given a certain environment, he will develop a high degree of musical ability. Musical ability here means talent for becoming a musician under proper training. Obviously, not everyone has this ability to any marked degree. Now, it may be found that only those children whose environment displays certain characteristics have this potential musical skill. On the contrary, we may find that environments can vary enormously without affecting the capacity of children dwelling in them to respond to a musical education. In that case, musical ability would be hereditary. At the same time, an abnormal environment would clearly hamper the development of musical ability. Partial starvation in early life, confinement in a dungeon, or severe injuries to the brain would prove fatal to such development. Thus an extremely abnormal environment could prevent the development of musical capacity, in spite of the strongest hereditary tendencies. To call any environment normal which is not extremely abnormal may seem too vague a conception, but it is necessarily inclusive. Hence, to term a capacity hereditary means that its development will depend upon heredity only providing environmental conditions are "normal."

Methods of Investigation.—The part played by heredity in the determination of an individual's mentality has been studied by two widely different statistical methods. One of these makes constant use of coefficients of correlation, and may be termed the *correlational or biometrical method;* the other traces family histories, and may be called the *pedigree method.*

The correlational method utilizes measurements of a certain trait for two members of the same family, say the father and the son, in a large number of families. Two lists of measurements are thus secured, one for fathers, and one for sons, the measurement for each son being paired with that of his father. Then the coefficient of correlation between these two lists is determined, and called the amount of correlation between father and sons with respect to the trait measured. This coefficient shows to what extent the standing of the fathers agrees with that of their sons. In a similar way correlations are calculated between brothers, or between fathers and daughters, or grandparents and grandchildren.

The correlational method, unlike the pedigree method, does not trace out all the members of each generation. The correlational method gives the amount of resemblance existing on the average between persons related to each other in a specified manner; for example, as father and son, or as brothers. The pedigree method, on the other hand, records what proportion of the offspring are like one or the other of their parents, for many successive generations. The correlational method may show that sons lack fifty per cent. of equalling their fathers exactly in height. The pedigree method, on the other hand, classifies fathers as tall, medium or short, and then gives the percentage of sons who fall in the same class as their fathers.

The fundamental assumption of the correlational method is that the greater the influence of heredity the greater will be the resemblance between relatives of any specified degree of relationship. It is noteworthy, however, that even where heredity is undoubtedly the cause of a trait, the resemblance between relatives in that trait is far from perfect. In a trait as unquestionably determined by heredity as color of the eyes, there may be in many particular cases no resemblance between parent and offspring. Among the children of brown-eyed parents may be some with dark eyes and some with blue; but the blue-eyed children owe the color of their eyes to heredity no less than do the brown-eyed. Children do not originate from the eyes, but from the germ-cells of their parents; and the color of children's eyes is determined not by the color of their parents' eyes but by the nature of their parents' germ-cells. Characteristics of a parent's body or mind are no sure indication of the characteristics of his germ cells.

Besides the difference between the germinal and the bodily traits of a parent, numerous considerations prevent a perfect resemblance between parents and offspring, even in purely hereditary traits. If the two parents differ in any trait, as they are likely to do, then, in spite of heredity, the resemblance of the children to one or both of the parents must be imperfect. Again, some traits (or their absence), may be caused either by heredity or environment. The cases in which a trait is caused by environment lowers the correlation of all cases taken together, and thus brings it about that the resulting coefficient of correlation conceals the fact that in many cases the trait is purely hereditary. For these and other reasons, heredity, when influential, merely causes persons of the same family to resemble each other more than persons who are not kin. In no case can it be expected to produce anything like a perfect resemblance, either between child and parent or between children of the same parents.

Results of the Correlational Method.—Because correlations are always far from perfect, the results of the correlational method are somewhat inconclusive and difficult of interpretation. The best way to arrive at an idea of the significance of the correlations of mental traits is to compare them with the correlations of physical traits. Many physical traits, like the color of the hair and of the eyes, and the shape of the head, are certainly not affected to any great degree by environmental factors. The correlation between father and son in such physical traits is always nearly thirty per cent., and that between children of the same family about fifty per cent. Now if mental traits prove to have the same correlation between parents and offspring as these physical traits, then parents and offspring may be said to show the same resemblance in mental traits as they do in purely hereditary, physical traits.

As a matter of fact, the correlations for mental traits and for physical traits are substantially the same. Practically all the numerous investigations conducted lead to this conclusion, a conclusion of great practical importance, whatever its interpretation.

One particularly interesting investigation is that by Karl Pearson,[1] who obtained teachers' ratings for a number of psychological traits in the case of one thousand pairs of siblings. (*Siblings* are children of the same parents; a pair of siblings consists of two brothers, two sisters or of a brother and a sister.) The traits included were: Ability, vivacity, conscientiousness, popularity, temper, introspection or tendency to self-consciousness, assertiveness and handwriting. The teachers' ratings of these traits, made without the aid of any special tests, and on a scale distinguishing only a few different degrees of the trait rated, do not constitute very accurate measurements. Nevertheless, the ratings by three teachers, acting without consultation among themselves, showed fair agreement. By means of these ratings, Pearson secured a list of measurements for each trait, and for each measurement of one child he had a corresponding measurement of another child of the same parents. He was thus able to calculate the correlation between children of the same parents. The correlation was least in vivacity, greatest in ability and handwriting, but varied only from forty-three to fifty-six per cent., and averaged slightly over fifty per cent., which is practically the same as for physical traits.

Another interesting investigation was made by Schuster and Elderton,[2] who, to obtain data bearing on the inheritance of mental ability, made a study of the class lists of Oxford College and of the schools of Harrow and Charterhouse. They noted the class standings of members of the same family, and then figured out the correlations. Expressing the resemblance between fathers and sons, a correlation coefficient of thirty per cent. was obtained, which agrees perfectly with the coefficients obtained in the case of physical traits.

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[1] "On the Inheritance of the Mental and Moral Characters in Man" *Biometrika,* vol. iii, 1904, pp. 131–190.

[2] "The Inheritance of Ability." *Eugenics Laboratory Memoirs,* 1907.

Other investigators have found similar correlations. Woods, in a well-known study,[3] rated 671 members of European royal families on a scale of ten, basing his ratings upon statements of historians and biographers. He found a correlation of intellect and character between fathers and offspring amounting to thirty per cent. Earle[4] measured the spelling ability of one hundred and eighty pairs of siblings in one of the schools of New York City. Using carefully prepared tests, and grading each child by his deviation from the average for his grade and sex, he found a correlation of fifty per cent. between siblings.

These investigations and others clearly demonstrate that mental characteristics or capacities run in families to just the same extent as do the color of the eyes or hair, or round-headedness and long-headedness. These physical traits are unquestionably determined almost entirely by heredity. Consequently, mental traits run in families very much as though they were wholly determined by heredity. Nevertheless it is not safe to conclude that mental traits *are* determined by heredity as much as physical traits. It must first be proved that the family resemblances were not produced by early home environment, especially the influence of fathers and mothers during the early years of life. The task of unravelling the effects of environment from those of heredity has been attempted in various ways; but it is a complex one, and so far has not been satisfactorily mastered. The evidence gathered, however, lends support to the belief that heredity rather than environment is the preponderating factor in the causation of individual differences in mental capacity.

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[3] "Mental and Moral Heredity in Royalty." 1906.

[4] "The Inheritance of the Ability to Learn to Spell." *Columbia Contributions to Philosophy, Psychology and Education,* vol. ii, 1903, pp. 41–44.

Certainly many of the factors that come first to mind in connection with environment are of very little consequence in determining individual differences. These are such things as bad housing, low wages, uncleanliness, unsanitary surroundings, unhealthy trade of the father, drinking and immoral behavior of parents, crowded rooms, condition of clothing, and so on. The effect of variations in such factors, which are everyday experiences—variations producible by political, economic or social control—has been measured. The correlations found between any one of these environmental factors and the mental traits of children is always very low, usually only three or four per cent.; and Karl Pearson has shown that when the correlations for each of these more or less closely related environmental factors is as low as this, the correlation for even a hundred of them taken together would still be so small as to indicate that their combined influence does not approach that of heredity.[5]

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[5] "On Certain Errors with Regard to Multiple Correlation Occasionally Made by Those Who Have Not Adequately Studied This Subject." *Biometrika,* vol. x, 1914, pp. 181–187. See also Elderton, "The Relative Strength of Nurture and Nature." *Eugenics Laboratory Lecture Series,* vol. iii, 1909, p. 40.

Thorndike,[6] like Francis Galton,[7] attempted to solve the problem by studying twins. He gave several mental tests to a considerable number of twins, and found members of twin pairs to show much greater resemblance than do ordinary brothers and sisters. He points out that if the high resemblance of twins is "due to the fact that the two members of any twin pair are treated alike at home, have the same parental models, attend the same school and are subject in general to closely similar environmental conditions, then twins should, up to the age of leaving home, grow more and more alike."[8] On the other hand, the nearer the resemblance of young twins comes to equalling that of older ones, the more must the resemblances be attributable to inborn nature. Thorndike found the older twins to show no closer resemblance than the younger twins, and hence concluded that the influence of environment was slight. It should be pointed out, however, that Thorndike's data do not, unfortunately, extend to twins below the age of nine. It still remains possible, therefore, that the great resemblance between twins is due to the action of similar home environment, exerted at a very early and impressionable age.

These studies of Pearson and Thorndike indicate that the only very important environmental factors in determining individual differences are of two sorts. The one is the direct psychological or educational influence of the parents during the very early years of life; the other is the nutritional and physical welfare of the brain during its early growth, both before and after birth. Among the physical factors most likely to interfere with nutrition of the brain are injury and disease affecting either the child or its mother. It is known that these factors are powerful enough in some cases to produce severe feeble-mindedness.

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[6] "Measurements of Twins." *Archives of Philosophy, Psychology and Scientific Methods*, vol. i, No. 1, 1905.

[7] "Inquiries Into Human Faculty," 1883, pp. 216–243.

[8] "Educational Psychology," second edition, 1910, p. 90.

Pedigrees of the Feeble-minded.—The case against environment as a cause of individual differences in children is made still stronger by the data concerning the causation of feeble-mindedness. Here the pedigree method has been the main reliance. This method has been employed on a large scale by certain of our institutions for feeble-minded children. These institutions, by the aid of field workers, secure as complete a record as possible of the ancestry of the feeble-minded children whom they receive. The field workers visit the homes of the children, in the country or in cities, interview the parents and relatives, family physicians, neighbors, judges and other informants. They note carefully the mental and physical condition of the parents, sometimes administering mental tests, and secure facts about the ancestry of the child for as many generations as possible. These facts are charted in the form of family trees. Hundreds of these family histories have now been collected.

The most extensive account of such studies so far published is that by Goddard, who secured fairly adequate data on the family histories of three hundred feeble-minded children. Upon analyzing the records he came to the conclusion that nearly eighty per cent. of these children owed their feeble-mindedness to heredity. The priority in causation of feeble-mindedness which Goddard ascribes to heredity is in agreement with the estimates of the overwhelming majority of qualified experts.[9] Dr. Ashby, for example, in his testimony before the British

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[9] See Tredgold, "Mental Deficiency," 2d ed., 1916, p. 22.

Royal Commission on the Feeble-minded, stated that in at least seventy-five per cent. of the children he had examined, there was strong probability that the feeble-mindedness was hereditary, and that he had observed no special tendency for the development of feeble-mindedness in the children of alcoholics, or of women who suffer privation during the period of gestation, or in those children who live in unfavorable conditions subsequent to birth.

Most of the feeble-minded cases attributed by Goddard to heredity had family histories showing a large number of other cases of feeble-mindedness. In these cases, then, feeble-mindedness is inherited from feeble-mindedness: "in these cases, it is evident from the charts themselves that we are dealing with a condition of mind or brain which is transmitted as regularly and surely as color of hair or eyes." On the other hand, Goddard, like almost all other authorities, attributes a certain percentage of feeble-mindedness to neuropathic ancestry; that is, he regards it as hereditary, but as inherited, not from feeble-minded ancestors, but from ancestors who suffered from such things as insanity, paralysis, apoplexy and epilepsy. It may be in these cases that the determining inheritance is merely a weakened constitution of the brain which develops into feeble-mindedness as the result of any of a long list of untoward circumstances such as falls, severe sickness, brain disease, convulsions or injury at birth, or disease or injury of the mother before the birth of the child.[10]

The analysis of Goddard's material brings out further interesting points. One is the result of matings in which both parents are feeble-minded. It appears that in this case, all the children, with rare exceptions, will be feeble-minded. Goddard's histories show 144 matings where both parents were feeble-minded. From these 144 matings there sprung 482 children who lived beyond infancy, and of whom information was obtainable. All but six of these 482 were feeble-minded.

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[10] See Tredgold, *op. cit.*, pp. 25–26.

To Goddard's cases in which both parents were feeble-minded, there could be added many more of the same sort. I have met with several of them, and in one case, besides visiting the entire family, obtained the intelligence quotients of seven of its members. The father of this family, when he works at all, collects ashes and garbage. The mother is too feeble-minded to manage the housework. The whole family is filthy and verminous. They live in a little, tumbled-down shack, on the outskirts of a small town. Members of a neighboring Lutheran church occasionally spend several days "cleaning house" for the family, but within a week things are as dirty as ever. There are eleven children, all feeble-minded. Three are old enough to work, but seldom do. The fourth child, Clara, aged 16 years and 8 months, quit school last September, in the fifth grade. The remaining seven are all younger than Clara, and still in school. Their intelligence quotients, together with their school grades, are as follows:

	I.Q.
1st grade: Walter	.69
2d grade: Jennie	.74
4th grade: Alma	.70
5th grade: May	.64
5th grade: Kate	.78
6th grade: Maud	.50
6th grade: Hannah	.66

The first of these children to attract my attention was Maud. Maud entered school at the age of five years, and spent two years in each grade except the first. She has been promoted, regardless of attainments, in accordance with the custom of promoting children who have been two years in a grade. She will never be promoted beyond the sixth grade, however, for as soon as she is sixteen years old, she will be asked to stay at home. She is now 15 years and 3 months chronologically, and 7 years and 6 months mentally.

The result of marriage between a feeble-minded person and a normal one is more problematic. According to Goddard, we must distinguish two kinds of normals: First, those who, normal themselves, have a feeble-minded parent or other ancestor, and are therefore capable of transmitting feeble-mindedness; and, second, those who are not only normal themselves but whose ancestry is entirely free from feeble-mindedness. Matings of feeble-minded persons with normals of the first sort, Goddard finds, cause one-half of the children to be feeble-minded. Matings of feeble-minded persons with normals of the second sort result in normal offspring, but the latter are all capable of transmitting feeble-mindedness to their children. Matings between such persons, normal themselves, but having a feeble-minded parent, result in the production, *on an average,* of three normal children to one feeble-minded child.

Figures showing definite percentages like these, if correct, prove clearly that there is a definite law of heredity which controls the transmission of feeble-mindedness. This law, which holds true of a vast number of animal and plant traits, as well as of a number of human traits, is known as Mendel's law.[11] Before it can be said to apply to the inheritance of intelligence, however, we need much more evidence than is yet at hand.

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[11] For an exposition of this law, see *Mendelism,* by R. C. Punnett.

The Kallikak Family.—Perhaps of all the family pedigrees so far published none so strikingly proves the hereditary nature of feeble-mindedness as that which Goddard has published under the title, "The Kallikak Family." Our discussion of the heredity of feeble-mindedness would be very incomplete without a description of this famous set of pedigrees. In tracing back the ancestry of a feeble-minded child called Deborah, the field workers arrived at the child's great-great-great-grandfather, called Martin Kallikak. Martin Kallikak, it was ascertained, was of fair intelligence, but when fifteen, owing to his father's death, was left without paternal guidance.

"Just before attaining his majority, the young man joined one of the numerous military companies that were formed to protect the country at the beginning of the revolution. At one of the taverns frequented by the militia, he met a feeble-minded girl by whom he became the father of a feeble-minded son."[12] This feeble-minded son, given his father's name, Martin Kallikak, handed the name of Kallikak down to posterity with the mentality of his feeble-minded mother.

Martin, Sr., however, leaving the Revolutionary Army, married a respectable girl of good family, and through that union there originated another line of descendants of radically different character. Thus there are two lines of descendants, starting with Martin Kallikak, Sr., one of which arises from a mating with a feeble-minded woman, the other from lawful marriage with a normal woman.

The comparison of these two lines of descent, traced through six generations, is extremely instructive. The accompanying chart (Fig. 13) shows the first generations.

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[12] "The Kallikak Family," 1912, p. 18.

From the illegitimate son of Martin Kallikak have come 480 direct descendants. Definite data have been secured concerning 187 of these, which prove conclusively that 143, or about 75 per cent., are feeble-minded. It is not improbable that the same ratio would hold for the other cases concerning which definite data could not be secured. In addition to feeble-mindedness, there was found a liberal admixture of illegitimacy, gross sexual immorality and drunkenness.

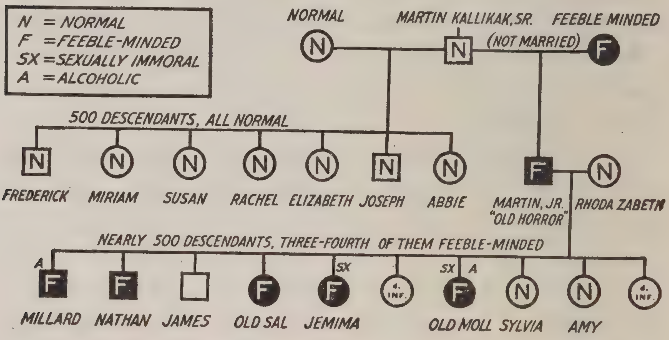
N = NORMAL
F = FEEBLE-MINDED
SX = SEXUALLY IMMORAL
A = ALCOHOLIC
NORMAL
MARTIN KALLIKAK, SR.
FEEBLE MINDED
(NOT MARRIED)
N
N
F
500 DESCENDANTS, ALL NORMAL
N
N
N
N
N
N
N
F
N
FREDERICK
MIRIAM
SUSAN
RACHEL
ELIZABETH
JOSEPH
ABBIE
MARTIN, JR. "OLD HORROR"
RHODA ZABETH
NEARLY 500 DESCENDANTS, THREE-FOURTH OF THEM FEEBLE-MINDED
A
F
F
F
SX
F
d. INF.
SX
A
F
N
N
d. INF.
MILLARD
NATHAN
JAMES
OLD SAL
JEMIMA
OLD MOLL
SYLVIA
AMY

FIG. 13.—Descendants of Martin Kallikak, Sr., by his wife, and by a feeble-minded girl. (Modified from Goddard, "*The Kallikak Family*," p. 37.)

On the other hand, from the union of Martin Kallikak, Sr., and his lawful wife, have come 496 direct descendants, every one of whom is normal. "In this family and its collateral branches, we find nothing but good representative citizenship. There are doctors, lawyers, judges, educators, traders, landholders, in short, respectable citizens, men and women prominent in every phase of social life.

There have been no feeble-minded among them; no illegitimate children, no immoral women." [13]

The Inheritance of Superior Intelligence.—The Kallikak history, one of the most extensive and convincing yet published, is paralleled by many others. These histories show that there is no escape from the conclusion that feeble-mindedness is hereditary. But what about the other degrees of intelligence? The answer is that all the facts indicate that the higher degrees of intelligence follow the laws of heredity to just the same extent as do the lower degrees. Does not the Kallikak family itself present equal proof of the inheritance of "normal-mindedness" and feeble-mindedness? Of course in this case the exact degree of intelligence to be understood by "normal" is not indicated. But there are other studies which show that the highest degrees of intelligence, including genius, are hereditary. Indeed, it is Francis Galton's study of *Hereditary Genius* that first really opened for investigation the subject of mental inheritance. And the record of feeble-mindedness seen in the degenerate strain of the Kallikak family is no more remarkable than that of eminent ability displayed by the Edwards family. It is refreshing to turn from the inheritance of feeble-mindedness to studies of the inheritance of high ordered intelligence.

First, we may cite some statistical studies of Francis Galton and of Woods. Galton chose for his study the 977 most eminent men out of a population of nearly 4,000,000. Each of these men, therefore, ranked as 1 man in 4000 for eminent intellectual gifts. These 977 eminent men, it was found, had a total of 535 relatives of a degree of eminence equal to their own. Galton then showed that

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[13] *Op. cit.*, p. 30.

977 average men have a total of only 4 eminent relatives. Since the group of 977 eminent men had 535 eminent relatives, as compared with 4 for a group of the same number of ordinary men, it appears that an eminent man has on the average 134 times as many eminent relatives as has the average man. Galton concluded from his study that eminence does not depend upon training or opportunity but upon birth. He held that the possession of high social advantage does not lead to eminence unless accompanied by marked innate ability, and that the man who is gifted with innate ability of a high order will be able to rise through all the obstacles caused by inferior social rank.

Galton's statistical findings have been confirmed by the results of several other investigators. Woods, for example, whose study of heredity in European royalty has already been mentioned, collected data concerning the forty-six Americans who have statues in the Hall of Fame. He finds that these celebrities have a great many more eminent relatives than has the average person; that they are, as he says, " from five hundred to one thousand times as much related to distinguished people as the ordinary mortal is." [14]

The Edwards Family.—It remains to fill in these statistical generalizations with a bill of particulars. This we will do by a brief survey of the Edwards family, one of a number of distinguished American families described by Davenport. We cannot do better than to quote in full his description, based on genealogical manuscripts.

"From two English parents, sire at least remotely descended from royalty, was born in Massachusetts

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[14] "Heredity and the Hall of Fame." *Popular Science Monthly*, 1913, pp. 445–552. See also, Loewenfeld, "Ueber die Geniale Geistesthätigkeit," 1903.

Elizabeth Tuttle. She developed into a woman of great beauty, of tall and commanding appearance, striking carriage, 'of strong will, extreme intellectual vigor, of mental grasp akin to rapacity, attracting not a few by magnetic traits, but repelling' when she evinced an extraordinary deficiency of the moral sense.

"'On November 19, 1667, she married Richard Edwards, of Hartford, Connecticut, a lawyer of high repute and great erudition. Like his wife he was very tall, and as they both walked the Hartford streets, their appearance invited the eyes and the admiration of all.' In 1691, Mr. Edwards was divorced from his wife on the ground of her adultery and other immoralities. The evil trait was in the blood, for one of her sisters murdered her own son, and a brother murdered his own sister. After his divorce Mr. Edwards remarried and had five sons and a daughter by Mary Talcott, a mediocre woman, average in talent and character and ordinary in appearance. 'None of Mary Talcott's progeny rose above mediocrity and their descendants gained no abiding reputation.'

"Of Elizabeth Tuttle and Richard Edwards the only son was Timothy Edwards, who graduated from Harvard College in 1691, gaining simultaneously the two degrees of bachelor of arts and master of arts—a very exceptional feat. He was pastor of the church in East Windsor, Connecticut, for fifty-nine years. Of eleven children the only son was Jonathan Edwards, one of the world's great intellects, preëminent as a divine and theologian, president of Princeton College. Of the descendants of Jonathan Edwards much has been written; a brief catalogue must suffice: Jonathan Edwards, Jr., president of Union College; Timothy Dwight, president of Yale; Sereno Edwards Dwight, president of Hamilton College;

Theodore Dwight Woolsey, for twenty-five years president of Yale College; Sarah, wife of Tapping Reeve, founder of Litchfield Law School, herself no mean lawyer; Daniel Tyler, a general of the Civil War and founder of the iron industries of north Alabama; Timothy Dwight, the second, president of Yale University from 1886 to 1898; Theodore William Dwight, founder and for thirty-three years warden of Columbia Law School; 'Henrietta Frances, wife of Eli Whitney, inventor of the cotton gin, who, burning the midnight oil by the side of her ingenious husband, helped him to his enduring fame; Merrill Edwards Gates, president of Amherst College; Catherine Maria Sedgwick, of graceful pen; Charles Sedgwick Minot, authority on biology and embryology in the Harvard Medical School, and Winston Churchill, the author of Coniston.' These constitute a glorious galaxy of America's great educators, students and moral leaders of the Republic.

"Two other of the descendants of Elizabeth Tuttle through her son Timothy have been purposely omitted from the foregoing catalogue, since they belong in a class by themselves, because they inherited also the defects of Elizabeth's character. These two were Pierrepont Edwards, who is said to have been a tall, brilliant, acute jurist, eccentric and licentious; and Aaron Burr, Vice-President of the United States, in whom flowered the good and the evil of Elizabeth Tuttle's blood. Here the lack of control of the sex-impulse in the germ plasm of this wonderful woman has reappeared with imagination and other talents in certain of her descendants.

"The remarkable qualities of Elizabeth Tuttle were in the germ plasm of her four daughters also: Abigail Stoughton, Elizabeth Deming, Ann Richardson, and

Mabel Bigelow. All of these have had distinguished descendants, of whom only a few can be mentioned here. Robert Treat Paine, signer of the Declaration of Independence, descended from Abigail; the Fairbanks Brothers, manufacturers of scales and hardware at St. Johnsbury, Vt., and the Marchioness of Donegal were descended from Elizabeth Deming; from Mabel Bigelow came Morrison R. Waite, Chief Justice of the United States, and the law author, Melville M. Bigelow; from Ann Richardson proceeded Marvin Richardson Vincent, professor of Sacred Literature at Columbia University, the Marchioness of Apesteguia of Cuba, and Ulysses S. Grant and Grover Cleveland, presidents of the United States. Thus two presidents, the wife of a third and a vice-president trace back their origin to the germ plasm from which (in part) Elizabeth Tuttle was also derived, but of which, it must never be forgotten, she was not the author. Nevertheless, had Elizabeth Tuttle not been, this nation would not occupy the position in culture and learning that it now does."

Conclusion.—It is clear, from whatever angle the subject is studied, that heredity is an enormously important factor in determining a person's mental characteristics. It is not altogether a simple matter, however, to decide upon the exact interpretation to give all the interesting facts that have been gathered. Perhaps the main point established is simply the fact of innate capacities. Since innate capacities are determined by the action of heredity, difference between children in innate capacities must always be due to heredity.

But certainly one other point is established: that environments may be very diverse and still be equally suited to the manifestation of such innate capacities, or the lack of them, as may exist. The environments of most children, especially those in the same community, in spite of great apparent diversity, are after all sufficiently alike, so that differences in ability are almost entirely accounted for by differences in innate capacity, and not by differences in environment. When the environments of children are at all similar, we find that such differences in environment as may exist do not correlate with the degree of success of the children's performances. The degree of success must consequently depend upon the innate potentialities of the children.

Even though the capacities of an individual are not determined entirely by heredity, they might just as well be, so far as the public schools are concerned: for the only environmental factors of importance in the determination of original capacities are those which act at a very early age—often at or before birth, or during the first few months of life. Certainly, both *specific* capacity, as the ability to learn to write the opposites of words or the ability to become a musician, and *general* capacity as shown by the intelligence quotient, are determined before the child enters the public school. The *rate* at which children's capacities grow is still subject to some variation after the school age is reached; but probably if proper allowance were made for these varying rates of growth, there would be found practically no change in any child's ranking as regards any of his original capacities.

In all this, it should be remembered always that we are referring to capacities, and capacities are merely potentialities. Whether these potentialities are ever realized certainly depends upon environment. It is true that an environment highly favorable to the manifestation of a certain capacity cannot result in such manifestation unless the capacity is there: the most favorable environment in the world cannot bring about the manifestations of normal intelligence in a case of hereditary feeble-mindedness. On the other hand, an unfavorable environment, though it cannot easily suppress an existing capacity nor its growth with age, can yet suppress the manifestation of that capacity. In the words of Cattell, "the environment imposes a veto on any performance not congenial to it."[15] Capacities are innate, but it is environment and education which determines the use, if any, made of them, and the line of accomplishment to which they are directed.

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[15] "The Development of American Men of Science." *Science,* Dec. 7, 1906.

CHAPTER XIII

THE ORGANIZATION OF EDUCATION

The Relation of Education to Heredity and Growth.—The results discussed in the preceding chapter clearly demonstrate that there is such a thing as original capacity, capacity determined by heredity or by physiological factors very early in operation. Original capacity, whether intelligence or special talent, is fixed before the age for entering school. With this fact established, it is easy to see that the object of education must be the provision of exercise for these capacities—not the creation of them. Capacities are simply potentialities—possibilities—which the school must transform into realities, by giving them opportunity to manifest themselves. The task of the school is nothing other than to arrange for all children the chance to use whatever capacities they may possess. It is only through use that the child's capacities may be trained to accomplish their maximum.

I have emphasized the distinction between original capacity and the opportunity for its training through exercise. It is necessary at this point to make one more distinction, that between training and growth. Original abilities, although inherited, are not inherited in their final form. Present at birth, they still have before them a long process of growth, as have the brain and the nervous system, in which they find their physiological basis. The process of growth of an organ, and the rate at which it grows, are as largely due to heredity as its very existence. Growth in mental ability, then, should not be confused, as it so frequently is, with the effects of training. Growth changes the amount of capacity; education enables the individual to accomplish the maximum with such capacity as he may possess. The distinction is clear enough in adults, who go on learning all their lives, but who stop growing in intelligence at fourteen or fifteen. I have pointed out, too, that the change in ability represented by the change from one mental age to a higher one should be regarded not as the result of education or training, but as a matter of growth.[1]

It is probably true that very early training of mental capacities has something to do with their growth. Probably at an early age the brain cells need stimulation through the avenues of the senses, just as they need nutrition from the blood, in order to attain their maximal growth. They need education as well as nutrition—a psychological environment as well as a physiological one. If newborn kittens are blinded before their eyes open, there results a degeneration of the cells of the visual area of the cerebral cortex. This points to the desirability of a broad experience early in life, so that as many brain pathways as possible will receive the stimulation necessary for their proper growth.

The effect of education or environment on the growth of innate abilities, however, should not be overestimated. The evidence of its importance in affecting growth, even at an early age, is not strong. We have very little definite knowledge of the manner by which educational or psychological environment, consisting of the stimuli which act on the senses, and regarded as separate from the nutritional environment consisting of the blood, may affect the growth of brain cells. Moreover, even if that knowledge were more definite, even though we were sure that the effect of environment on the growth of the brain cells was considerable, it is quite certain that this effect is exerted before the age of entering school. The evidence for this early fixation of a child's mental capacities I have already reviewed. It consists in studies of the growth of the brain, studies of the constancy of a child's brightness as he increases in age, and in studies of the heredity of mental traits. It is conclusive, and we cannot discount it. It proves that on the average, mental abilities, in the sense of capacities, are fixed before the school age. At this age, the capacities have either completed their growth or will do so independently of education.

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[1] See Chapter II, p. 37.

The work of the school, then, is no more to produce growth of capacities than to create them. The schools cannot bring out of a child what the good Lord never put into him. The business of the schools is to see that the child has the chance to show what *is* in him.

The accomplishments by which an original ability may manifest itself depend upon environment and education. Two children may have the same original ability, and yet, on account of the different opportunities afforded by their environment, show the utmost divergence in final achievements. Indeed, whole races may be largely illiterate or not, according to the organization of their schools and society. For example, the population of Mexico is known to have a large percentage of illiterates. Are we to conclude that this large percentage has not sufficient innate ability to acquire the art of reading? By no means. Send the children of these Mexicans to a good school for eight years, and undoubtedly almost all of them would learn to read and write. Differences in original ability would be evidenced by the superiority of some children in reading and writing, with no better instruction than others; but without instruction or opportunity even superlative ability is futile.

Lester Ward has gone so far as to argue that many men and women of genius have appeared in the world and died without an opportunity to win recognition as such. In so far as he means merely to distinguish between the possession of ability and the chance to manifest it, there is no reason for disagreeing with him. Of course it is a sign of genius to be able to create the opportunity for its own display. But it may be impossible even for a gifted man to create the opportunity for display of *all* his genius. And if this is hard for the adult genius, how much harder must it be for the child genius! As for the exceptionally dull child, nothing is clearer than the utter impossibility of his creating for himself the most favorable environment for the use of his abilities. Clearly, it is the duty of the school to provide the child with the proper environment, one that offers him the opportunity and incentive to exercise the best of his mental abilities.

To provide an environment suited to the child's abilities, the school must know two things: It must know the nature of the child's abilities, and the best environment for their exercise. Often it knows neither. Probably no one is certain about the best schooling for exceptionally bright children, and the schools are only beginning to show signs that they realize the existence of such children. Our knowledge has, however, made great progress. The methods for determining original abilities have been discussed in the preceding chapters. It remains to consider the educational environment suited to the different degrees of ability. The remainder of the present chapter will accordingly be devoted to consideration of the relation of innate dullness and superiority to the organization of education, and the following chapter to their bearing upon methods of education.

The Necessity of Special Education for Bright and Dull Children.—Obviously, before any methods of training can attain very much success, there must be a proper adjustment of the methods used to the pupils concerned. This requires a proper organization of the school, an administration which maps out in broad lines the objects to be accomplished and makes sure that each teacher is engaged in the right work with the right children.

The point of fundamental importance for public school organization is that different training should be provided for the dull children than for the superior ones. The school must recognize individual differences; and the most fundamental is in general intelligence. Even were it desirable that all children should learn the same things, some of them, it must be recognized, learn more quickly than others; some learn in six years what others master only in ten years. This is due primarily to the fact that the superior children *grow* in intelligence much faster than the dull; so that with increase in age there is constantly an increase in the difference in mental age between the two classes. Children of the same mental age at the time of entering school do not long remain of the same mental age. In a few years, the brighter children are well ahead of the duller ones, although the instruction is identical. As the brighter children outstrip the dull in mental age, they show a greatly superior learning power, for power to learn goes hand in hand with mental age.

It is not merely the difference in rate of mental growth, however, which necessitates a difference in instruction: it is not merely that the dull child progresses more slowly than the bright: he needs to be taught different things; for him the emphasis must be differently placed; in short, he needs a different *quality* of education. The capacities of most valuable service to the dull child are not those which form the most valuable assets of the superior child. Consequently, the environment required for the exercise of a child's best capacities is different for the dull and for the bright. A properly organized school must therefore make provision not only for different rates of progress, but must at the same time arrange for the adaptation of training to the kind of child receiving it.

Different rates of progress are obvious; but the statement that dull children need a different kind of training from bright children needs further elucidation. Does not a public school education, it may be asked, consist inevitably of reading, writing and arithmetic, with a little geography, history, manual training and grammar? It usually does, and very properly so. But the conventional curriculum, however wisely formulated, should not be set up as a rigid standard to which all children must conform; to suit the needs of a large percentage of children it must be radically modified.

All authorities now agree that the dull child needs a more immediately practical education than the normal child. He must be taught to do something useful, and with the least possible expenditure of time and money. A great step forward has been taken in the provision of auxiliary classes for these children; but in spite of rapid progress there is still a great waste in trying to give the children of these classes instruction in branches of learning which they can never master. The principle to follow is to teach only those things which the child can without doubt master sufficiently to make of them a real asset in such life work as he can be trained to do successfully.

If this principle is to be followed, education must be based on a diagnosis of mental capacities which takes into consideration not simply the child's mental, anatomical and chronological ages, but his entire history, background and constitution. On the basis of such diagnosis a rough and tentative estimate can be made of the sort of life-work which the child may ultimately make his own. Suppose, for example, that we have to do with a feeble-minded child who seems likely never to go much beyond the mental age of seven or eight. We know that such a child can never learn arithmetic, or even reading and writing, sufficiently for them to be a real help to him, and that the attempt to teach him these subjects is simply a great waste of time, effort and money.[2] If a child's intelligence quotient is below 0.70, it is useless to attempt instruction in arithmetic beyond addition, subtraction, multiplication, division and very simple fractions; if it is below 0.40, instruction in reading, even, is useless.

There are innumerable examples like that of the boy[3] who spent seven years in one of the special classes in Cleveland, after attending the regular grades for three years. At last he was triumphantly able painstakingly to write such words as "my," "see," and "dog," but unable to read them after he wrote them. His "education" cost the city one thousand dollars.[4] Not to apply our knowledge that instruction in the three "R's" in such cases as these is utterly futile, now that we have by a costly experience gained that knowledge, is criminal folly.

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[2] See Goddard, "School Training of Defective Children," 1915, pp. 9–12.

[3] Mitchell, "Schools and Classes for Exceptional Children." *Cleveland School Survey*, 1916, p. 69.

[4] For similar cases, see Chapter I, pp. 11, 12 (Abbie) and Chapter XI, pp. 243, 244 (Clara and Maud).

What, then, should be the education of a child who is not likely to exceed the mental age of seven or eight, if it is to contain no instruction in reading, writing or arithmetic? It must consist essentially of training in some of those things which experience has shown a person of these low mental ages able to accomplish fairly well. He may succeed at many varieties of manual work. The kind of manual work best suited to each mental age has now been worked out in considerable detail. A girl of mental age seven, for instance, may be taught to do well any of the following occupations: Washing dishes, setting table, scrubbing, and other forms of housework; sewing and simple tailoring operations; lace-making; rug weaving; and ironing and sorting clothes. A man of mental age seven may do good work at any of the following: Housework, such as sweeping and polishing; laundry work; "outside work," such as taking care of a lawn, using pick and shovel, or teaming; brush making; some bench work; and net work—the making of tennis nets or hammocks.[5]

It is a very conservative estimate, that at least the dullest ten per cent. of the average school population require a special education, an education which must differ from that of the normal in being more practical, more devoted to vocational and industrial training. It must consist more in physical activity and less in book learning. It must prepare the child by the shortest and most economical route for the best service to the community that he has it in him to render, however humble that service may be.

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[5] Merrill, "The Ability of the Special Class Children in the 'Three R's.'" *Pedagogical Seminary,* vol. xxv, 1918, pp. 88–96.

That the special education of the supernormal child is of even greater importance than that of the dull child is not so readily recognized. Whereas the dull child is an ever-present source of trouble to the teacher and a hindrance to her work with the children who are more justly entitled to her time, the exceptionally bright child easily takes care of himself. Although he may be a source of disorder, because he is not sufficiently occupied to find the school work interesting, he keeps pace with the rest of the class without difficulty. This apparent success of the bright child blinds the teacher to the fact that, in view of his superior capacities, he is accomplishing far less than he should. It is clear, however, that a child who is to grow up to be a leader in society deserves a much more advanced training than one who can barely be trained to self-support. If we continue to use a large portion of our energies in training the children of the lower levels of intelligence, without simultaneously devoting special attention to the exceptionally bright, we shall produce an unbalanced system, which must in time tend to pull downward the general level of education.

In the ordinary schoolroom, the superior child obtains far less knowledge and training than he can assimilate, less than he must receive if his abilities are to be exerted to their utmost. The exceptionally bright child is capable of turning to advantage a very great variety of knowledge. His education consequently must be broader than that of the majority. It should include more branches of study, and more advanced study of the subjects taught to the average children, extra problems and extra study of special topics. The details of the program cannot be formulated until we have a much larger mass of really scientific data. Hitherto our knowledge of supernormality in youth has been confined merely to fragmentary information of the boyhood days of great men and scattered accounts of infant prodigies—as unreliable as they are sensational. An enlightened educational procedure for these children still awaits the results of a systematic study of the supernormal, including not only a study of their mental traits, with related physiological conditions, but a careful record of their development during and after their school training. Only in this way will the proper system ever be established.

One occasional objection to special education of the supernormal child is that the additional demands made upon his mental ability may overburden him physically so as to endanger his health and physique. Undeniably, great care must be exercised on the physical side, but there is no evidence at hand to show that a bright child engaged in mental work which challenges his best efforts is thereby doing himself a physical injury. There is danger, no doubt, but harm can be avoided by proper attention to all matters of health and hygiene, and by consideration of these latter forces before purely mental development. In this connection, a knowledge of anatomical age is of great value. As a previous chapter states, no child should be pushed ahead mentally if his anatomical development is below the normal for his age.

Another objection, particularly strong in a democratic country like America, is that granting special attention to exceptionally bright children may cause them to feel superior to their schoolmates, and so develop in them a spirit of arrogance and intellectual conceit. The only way to avoid this is to make the special privileges accorded to these children dependent upon strength of character as well as upon mental capacity. Children should not acquire these privileges ostensibly for a high level of intelligence, but as a reward of hard work; and continued enjoyment of them should be made dependent upon persistence of effort, earnestness and faithfulness. By maintaining these character qualifications, there is little danger that a child will become conceited, particularly as he will compete with others of his own calibre rather than with those whom he can easily outclass.

According to Stern, one of the ablest of the few scientific students of education for the supernormal child, the moral dangers of the special class for very superior children are far less than those of the regular class. He summarizes his conclusions thus: "A school system adapted to the average is not merely uneconomical for those of unusual capacities. It is under some circumstances, positively morally dangerous, because, for such pupils, the completion of the assigned work is but play; the slow progress and frequent repetitions bore them; the deeper interests that they bring with them to the school are not enlisted. Consequently, indolence, laxity and dislike for school are readily developed; the spirit of hard work, self-control and conscientiousness that should spring from persistent effort fail to appear; in short, the higher ethical qualities that the school should bring into play are not developed in these pupils—a situation that is doubly deplorable because great mental gifts first make themselves fully evident when they are enlisted in the service of a firm, conscientious will." [6]

Stern believes that very remarkable results may be attained with children of superior mentality, in properly conducted special classes. In view of the absence of any scientific records, we cannot do better than again to quote his views. He writes, " By following a very different pace from ordinary classes, by broadening and deepening the cultural material, by minimizing drill and mechanical aids to memorization, by cultivating especially the habit of independent mental review and assimilation of the subject-matter and by free election within the subjects of instruction (particularly in the upper classes), the superior capacities of these pupils would be given the possibility of development for which their birth had fitted them; moreover, by reason of the quite unusual demands made upon them, self-discipline and the spirit of conscientiousness would also be developed in a manner totally impossible for such pupils in the ordinary school. And there would be developed for society a class of leaders equipped with really deeper and broader training." [7]

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[6] "The Supernormal Child." *Journal of Educational Psychology*, vol. ii, 1911, p. 148.

Stern's emphasis on the need of special education for the exceptionally bright child is echoed by numerous other authorities. Dr. Wallin, director of the Psycho-Educational Clinic of the St. Louis Public Schools, asserts that the supernormal child has been, more than any other, neglected.[8] Bonser thinks that " perhaps the worst type of retardation in the schools is withholding appropriate promotion from those pupils who are the most gifted, therefore of the most significance as social capital." He came to this conclusion from a study of the reasoning ability in children of the fourth, fifth and sixth grades.[9] He found that many children of the fourth grade possessed better mental powers than did children in the sixth grade, but that the graded system made no provision for the adequate development of these powers. Groszmann, who describes the early years of numerous exceptionally bright children, states his opinion as follows: "As long as the physical health and strength of children of this type keep pace with their mental development, there is nothing to fear. But they certainly need to be given the opportunity to live and learn according to their quickened rate. They must not be held back to chafe under the restraint of their vitality and initiative, and must be given tasks commensurate to their strength and ability to cover ground."[10]

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[7] *Op. cit.*, p. 183.

[8] " Clinical Psychology and the Psycho-Clinicist." *Journal of Educational Psychology*, vol. vi, 1911, p. 123.

[9] " The Reasoning Ability of Children of the Fourth, Fifth and Sixth Grades." *Teachers College, Columbia University, Contributions to Education*, 1910, p. 91.

Dr. Goddard estimates that about four per cent. of the children in the public schools possess mental ability so superior to the average child as to demand special opportunities in the way of special classes and courses of study for their development.[11] Groszmann, who points out that at present exceptionally bright children receive less attention than the feeble-minded and defective, though "they are infinitely more worth while," estimates that "their number is at least equal to the number of abnormals at the lowest end of the scale."[12]

Provision for Dull and Superior Children.—The problem of arranging for the special education of exceptionally dull and exceptionally bright children is a very complicated one. It should be viewed merely as part of the broader problem of adapting the school offerings as far as possible to the individual needs of all children, including the mediocre, or normal. A school system, to make adequate provision for individual differences, must take into consideration the following three factors: (1) Unequal rates of progress made by children of different degrees of brightness; (2) uneven progress in different subjects; and (3) a high degree of individual attention to each pupil in each and every class.

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[10] "The Exceptional Child," 1917, p. 117.

[11] "Two Thousand Children Measured by the Binet Measuring Scale of Intelligence." *Pedagogical Seminary,* vol. xviii, 1911, p. 236.

[12] *Op. cit.,* p. 139.

Some very elaborate systems have been devised, many of which include parallel courses. Thus, the well-known plan evolved in Cambridge, Mass., separates the pupils at the beginning of the fourth year into a slow and a fast division. The pupils of the fast division enter upon a program which completes the remaining work of the grades in four additional years; those of the slow division follow a program which includes the same work, but which is planned so as to consume six years. Since the fast group does in two years the same work which the slow finishes in three years, the two groups at the middle of their parallel courses arrive at the same point. It is then possible to reclassify the pupils. A pupil who has been in the fast group for two years may be transferred to the slow group and so finish in three more years, whereas a pupil who has been in the slow group for three years may be transferred to the bright group and finish with that group in two more years.

A more elaborate arrangement of parallel courses is the Mannheim system, established in 1899, in Mannheim, Germany. Its most distinguishing feature, perhaps, is the provision of "furthering classes." These classes are composed of pupils unable to keep pace with the regular classes. They are of seven grades, corresponding to the first seven grades of the regular course, but differing in that the work done in them is much less extensive. The children in these classes are not feeble-minded, they are simply dull, and include about ten per cent. of all the children enrolled in the schools. The great majority of the children in these classes are never promoted to the normal classes, but simply to the next furthering class. The system permits, however, of the transfer of a child from any of the regular grades into one of these furthering classes, or, on the other hand, from one of the furthering classes to the regular grades. For the feeble-minded children, there is provided a third course of study, the auxiliary school, which has only four grades.

Besides the furthering classes for the dull, and the auxiliary classes for the feeble-minded, the Mannheim system makes special provision for supernormal children, comprising extra instruction in French for the sixth, seventh and eighth grades. After a preliminary course in French in the fifth grade, those pupils who have made good progress in this language and at the same time continued their good record in other subjects, and who are above criticism in matters of conduct and industry, are admitted to the regular foreign language classes. Pupils whose work in the foreign language classes is poor are sent back to the regular classes.

Whether or not such a complex process as the Mannheim system is necessary, in order to adapt the means of education to the educability of the individual child, is a question. In small towns, at least, simpler methods will have to be devised. There is nothing superfluous, however, in the accomplishments of the Mannheim system; and any system which does not solve all the problems there taken into consideration has very grave shortcomings. The aim should be to accomplish not only as much as the Mannheim system but more. Further progress is needed particularly in the treatment of exceptionally bright children and in the matter of individual attention to all children, including always—the mediocre. Many people believe that the best provision for bright children can be made, from the seventh grade on, by combining the seventh and eighth grades in one system with the four years of high school. Such an arrangement, besides possessing independent advantages, permits the exceptionally gifted children to pursue various subjects of a high-school grade in addition to the regular work of the seventh and eighth grades. Linking the regular high school work with the upper grades facilitates the provision of special opportunities for the brighter pupils of those grades, particularly as the work of high schools, with its instruction by subjects instead of by grades, is itself usually organized upon a much more flexible basis than is that of the grades.

When it is feasible to keep the classes small, a fairly simple organization will suffice. Holmes suggests the following as satisfactory:

"The work would be based on what might be called a course of study in the fundamentals: this work would be so graded as to be within the powers of all normal children, both quick and slow. To it would be added a course of optional topics to be studied by the abler pupils largely by themselves, in order to develop initiative and self-direction. . . .

"Beginning, perhaps, at the sixth grade, the work would be somewhat differentiated without in the least breaking up the class organization."

As a chief feature, this plan requires a "supervisor of individual work." "This teacher would be in charge of the work of four or six rooms. In her hands would be the school welfare of all the individual pupils in these four or six rooms, but she would care especially for the abler pupils and also for the slow and backward. When an abler pupil had been promoted, of course she would see that he was adjusted to the work of the new grade."[13] As a rule, instead of one teacher to manage the education of both the brightest and dullest children, it is highly advisable to provide a separate teacher and room for each of these two classes of children.

The Problem of the Feeble-minded.—In most of our large cities, the outstanding feature of the provision for exceptional children is the auxiliary class, often called an ungraded class. In some schools there is simply one of these classes for all the different school grades; in other schools, the auxiliary classes themselves are graded, and correspond to the first four regular grades. The pupils in these ungraded classes are chiefly feeble-minded children, usually of the moron grade. Occasionally, however, one meets with a child of the imbecile grade, and, on the other hand, there may be numerous borderline cases or children who are merely backward.

These auxiliary classes usually contain from ten to fifteen children, who differ greatly in size and age, and who are likely to impress the visitor as a motley group, even in those schools which have several grades, so that the children may be classified by mental age. The schoolroom contains, instead of the usual desks, tables and chairs of various sizes, which, at times, may be pushed aside to clear the floor for games. Around the sides of the room are work-benches, cupboards and store-cases, for dishes, tools, and various teaching materials. Sometimes there is an additional room with a full kitchen and dining-room equipment. Where several of these classes are in the same building, there may be special rooms for manual training, for gymnastic exercises, for sewing, for cooking, and so forth. Sometimes one room is so equipped that it may be turned to any use that the instruction in hand makes desirable.[14]

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[13] Holmes, "School Organization and the Individual Child," 1912, pp. 84–86.

Communities possessing these ungraded classes usually miscomprehend their function. The idea is widespread that the business of these classes is to enable children, by means of miracles, to "catch up" with pupils in the regular grades. As a matter of fact, the great majority of the children in the ungraded classes, indeed, all who are properly there, can never be brought up to normal. Fortunately, this is now quite well understood by those in charge of these classes, if not by the community at large.

The establishment of these ungraded classes for the feeble-minded in the public schools by no means solves the problem of subnormal children. In connection with every school system having classes for feeble-minded children, there should be, in addition, classes for dull children above the grade of feeble-minded. Under various designations, such classes now exist in a number of our leading cities, in addition to the classes for the feeble-minded. In them are included not only *dull* children but also *backward* children, who for one reason or another are simply delayed in their mental development.

The public school ungraded classes for feeble-minded not only fail to solve the problem of the dull and backward children, but in a very serious degree fail to solve the great problem with which they are particularly concerned, that of feeble-mindedness. The auxiliary teachers do all that can be reasonably expected. The trouble is that the children of these classes do not go to school all their lives. The benefit received by the school training is lost and sometimes worse than lost in their subsequent careers. Some years ago a report was published giving the after-history of fifty persons selected at random from former pupils of ungraded schools of New York.[15] The findings were summarized in the statement that " the majority are utterly incapable." Only two of the fifty were found " to show signs of being able to hold permanent employment." In spite of the fact that these cases were all under twenty years of age, it was evident that in numerous instances the temptation to an immoral or even criminal life could not be resisted. Several of the girls, although feeble-minded, were engaged to be married; others had already found their way into some sort of " House of Refuge " or penal institution. The careers of the graduates of auxiliary classes show that in a large percentage of cases their training has failed to enable them to become independent and useful members of the community.

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[14] For further description, see Goddard, "School Training of Defective Children," 1915, pp. 19–27.

The proper solution of the great problem of the feeble-minded remains to be determined. There are numerous proposals. Some authorities are convinced that we must increase the number of our state and city institutions for the feeble-minded until there are accommodations for the whole feeble-minded population. This would mean that the existing facilities would have to be many times increased, for only a small fraction of the feeble-minded persons in the country, certainly not over a fifth, are now in institutions. Such additional provision, of course, would necessarily be coupled with a law giving to these institutions the right to retain in their custody all inmates likely to become sources of trouble to the community or to reproduce their kind.

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[15] Anne Moore, " The Feeble-Minded in New York," 1911, pp. 45-49.

Another proposal advocates the permanent custody of all feeble-minded persons except those who, by means of a surgical operation, have been rendered incapable of reproduction. With such provision, one or two generations would certainly behold great improvement. The problem would then be fairly simple. Of course new cases of feeble-mindedness would constantly develop. Not all feeble-mindedness is hereditary. It must originate before it can be inherited, and it will continue to originate in the future from the same causes as in the past. And it would always be impossible to relegate to institutions large numbers of the great mass of border-line cases. Certainly, though, the number could be so reduced that the burden would be comparatively light. Were there institutions enough for the great majority of existing cases, the number would more than suffice for future generations.

For the present, we must admit that the idea of putting all feeble-minded children under the control of institutions, unless they are sterilized, is an idle dream. The public has not yet been educated to the point of taking the drastic measures that are necessary to cope properly with the problem. Consequently, the immediately urgent thing, pending such education of the public, is to provide more thoroughly than at present for the after-care of the pupils who leave the ungraded classes of the public schools. In France, a Committee of Patrons is appointed in connection with every auxiliary school. Women must form a part of the membership. Some such committee should exist in this country for every ungraded class. Its duty would be to find employment suitable to the capacities and character of persons coming under its jurisdiction. A committee, however, no matter how charitably inclined, cannot be expected to act with the constant attention necessary for the after-care of the feeble-minded; and its authority would be limited. It would therefore seem desirable in addition to appoint, under the law, on salary and full time, especially qualified officers, to look after the feeble-minded persons of the community. Such officers could be discharged upon lax performance of duty.

If the feeble-minded are to mingle freely in society, we must, in addition to giving more attention to after-care, take pains to determine exactly who are the feeble-minded members of a community, and to enforce strictly the laws against their marriage. This requires the administering of group intelligence tests to the entire school population, and individual examination of doubtful cases. Thus, in the course of time, a list may be secured of all feeble-minded persons and their addresses. The after-care officers or committees, and those having authority to grant marriage licenses, should be furnished this list. At present there is no way of enforcing the laws against the marriage of the feeble-minded, because, with the exception of low grade cases, who are not likely to marry, the feeble-minded are not definitely known. In Minnesota, at the instigation of Dr. Kuhlmann, there is now being conducted a census of an entire county—a rather populous one. I have no doubt that when the importance of this work is publicly recognized, it will be extended to include the whole state. We must know who and where the feeble-minded are before we can care for them.

CHAPTER XIV

EDUCATIONAL METHODS

After organizing classes to adapt education to individual differences in brightness, it becomes necessary to consider the proper educational methods for use with different classes and different individuals within these classes. We must analyze the processes of which education consists and determine how they vary with differences in mental ability. We are not infrequently told that the principles of education are the same for a dull or feeble-minded child as for a normal or bright one. But what are these principles? Many of them are stated in published accounts of the education of the feeble-minded, but it is very doubtful whether any of them, as laid down, are applicable to the education of children displaying the higher degrees of brightness. The search for principles must be continued; and we may well begin it by an analysis of the methods that have for over a century been evolving for the education of the feeble-minded.

The Savage of the Aveyron.—Attempts to provide an education adapted to the needs of feeble-minded children go back to the sensational experiment made by Itard at the beginning of the last century on an idiot of eleven or twelve years of age, known as the "Savage of the Aveyron." First discovered by hunters, during the eighth year of the French Republic, in a wood in the department of Aveyron, France, entirely naked, and seeking his nourishment from nuts and roots, he led the life of a savage. He was unclean, made spasmodic and convulsive movements, showed no gratitude to those who aided him, attempted to bite and scratch those who coerced him, was able to make only a few animal-like sounds, and seemed altogether incapable of attention. Not only was he utterly wanting in the ability to speak, but even his gestures and bodily movements showed no trace of expression. He passed rapidly, and without apparent motive, from spells of pathetic sadness to violent outbursts of laughter. His sole manifestation of intelligence concerned the satisfaction of his gluttonous appetite; yet he lacked sufficient mental acumen to climb upon a chair in order to obtain food placed beyond his immediate reach.

Contrary to the opinion of Pinel, the great pioneer in the study of mental disorders, who held that the case was one of rank idiocy, Itard believed the boy was merely uncivilized, and possessed an intelligence simply untouched by any sort of education. Had he regarded the boy as an idiot, as one without intelligence, he would never have undertaken his training, for he viewed his labors as an experiment in the philosophy of mind, designed "to solve the metaphysical problem of determining what might be the degree of intelligence and the nature of the ideas in a lad, who, deprived from birth of all education, should have lived entirely separated from individuals of his kind."[1] For years Itard worked with utmost patience. He was constantly devising new and ingenious methods for awakening the senses of his pupil, for developing a power of speech, and for getting the boy to exercise his mind in the satisfaction of wants. At the end of five years of daily experimentation, Itard came to feel, as Séguin puts it, that "there were other impediments besides savageness in his pupil;" and in a report to the Minister of the Interior he confessed that his experience had been not so much one of progress of the pupil as of failure of the instructor. Notwithstanding this modesty, Itard recognized that the personality of his ward at the end of five years' training offered a sharp and wonderfully favorable contrast with its original condition.

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[1] Itard, "Rapports et mémoires sur le sauvage de l'Aveyron, l'idiotie et la surdi-mutité," 1894, p. 9. This work is a collection of reprints, which includes Itard's paper of 1801 on the early development of the "Young Savage of the Aveyron."

The improvement was summed up under three headings: First, there was a marked development of the senses; second, knowledge of language was acquired to such an extent that the boy could name objects, designate their qualities and uses, express his desires, understand orders, and, in the words of Itard, carry on "a free and continual exchange of ideas;" third, in spite of a persistent desire to enjoy the freedom of the fields and a marked indifference to the pleasure of society, there finally developed a sense of human relationship, manifested by signs of affection, by pleasure at having done well and by shame at bad conduct.[2]

How were these wonderful results accomplished? In general, by what has been called the physiological method, an elaborate series of ingenious procedures, later perfected and systematized by Séguin and described by him in great detail.[3]

The Physiological Method.—Séguin in 1837 founded the first school devoted primarily to the education of idiots, and was instrumental in founding some of the most famous of such institutions in America. His account of the physiological method was based upon a lifetime of practical experience in the education of idiots, and a better idea of its principles may be obtained from his exposition than from that of Itard, or, indeed, from any of his followers, for his work has never been surpassed.

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[2] Itard, *op. cit.*, pp. 105–106.

[3] "Traitement moral, hygiène et éducation des idiots," Paris, 1846. Also, "Idiocy, Its Diagnosis and Treatment by the Physiological Method." Albany, N. Y., 1864. Reprint published by Teachers College, Columbia University, 1907.

The fundamental principle of the physiological method is more easily stated than understood. It is based on the concept that an individual, although a unitary machine, has a number of interrelated faculties or "functions." Each sense is one of these functions, and so also are the capacities for motion and speech. Dependent upon the proper development of these functions are others, not systematically enumerated, such as memory, association, attention and reasoning ability. The fundamental principle is therefore that education should train the various functions or faculties by means of drill exercises. This operation contrasts with an education which aims merely at imparting information or knowledge.[4] Each function or faculty, each system of neurones, is developed to the fullest possible extent.

Montessori illuminates the method by her reference to experimental psychology. Her procedure, in principle like that of Séguin, she says is based on that of experimental psychology.[5] She considers experimental psychology to be a science which tests or measures the various senses and other functions. These tests involve sensory discrimination. For example, the experimental psychologist tests hearing by determining the smallest perceptible difference between two tones, in loudness or in pitch; color vision, by the smallest perceptible difference in the hue of two colors; and touch, by the smallest distance between two points applied to the skin which will permit of their recognition as two instead of one. Now Montessori's idea is simply that whenever a function is tested, it is exercised, and so by simply using tests suited to children, tests which interest instead of wearying them, the educator may turn the psychologist's measurements into exercises for the development of the senses. Every psychologist knows that any mental test can easily be transformed into a game, and that if he is willing to sacrifice the idea of measurement, the variety of games is considerable. For instance, instead of asking his subjects which of two tones is the louder, or the higher in pitch, familiar objects, differing in sound when dropped upon a table or shaken in a box, may be used, and the child asked to guess which object he has heard. Moreover, psychological tests can be classified according to the various mental functions which they test. Thus the physiological method is a number of more or less scientific exercises for the development of various functions or faculties.

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[4] Séguin, "Idiocy and Its Treatment," 1907, p. 28.

[5] Montessori, "The Montessori Method," third edition, 1912, p. 167.

The training of the senses and of motor ability has greatest prominence in the physiological method. None of the senses is ignored, not even that of smell or taste. They are trained mainly by acts of sensory discrimination or comparison. The sense of sight is trained by practice in the sorting of colors, such as sorting a box of variously colored pegs into piles each of one color. Similar sorting exercises may be for length, form or size, in place of color, or, instead of simply putting together those which are alike, the child may be trained to fit the pegs into peg boards or form boards. These exercises, particularly when the child is blindfolded, exercise the sense of touch. The sense of touch is further developed by having the child draw his fingers lightly over surfaces of various degrees of roughness with his eyes shut, until he is able to make fine distinctions. The sense of hearing is trained by identifying objects according to the sound they make, or by attempting to find on the piano a tone just sounded by the teacher. Great emphasis is laid also upon the use of music, not merely as a training for the ear, but as an aid to physical exercises, such as drill and dancing, and as a general stimulus to mental activity.[6]

Motor training, training in movement and action, is given by such exercises as cutting, folding, modelling, weaving and the use of tools. Imitation of the teacher's movements may also be used. At an earlier stage, it may be necessary to give training in elementary motor-coördinations, like those involved in standing and walking, and carrying objects. "Consequently," writes Tredgold, "the first exercises must be directed towards teaching the child to maintain a proper balance of the body, to run and to walk, to push and pull, to seize, to hold, and to let go, tolerably large objects. For this purpose such exercises as mounting a ladder placed against a wall, walking between the rungs of a ladder placed flat upon the ground, marching in, out, and over various obstacles to the accompaniment of music, and accurately covering with the feet a series of footprints chalked upon the ground, as recommended by Séguin, are of the highest service."[7] Catching and throwing a bean bag, picking up and carrying objects and innumerable other exercises are widely employed.

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[6] For further details, see Anderson, "Education of Defectives in the Public Schools," 1917, p. 104.

[7] "Mental Deficiency," 2d ed., 1916, p. 414.

In theory, the physiological method does not stop with the training of sensory and motor faculties, but usually it represents little else. However, even Séguin describes methods for the cultivation of memory and imagination and the moral sense, and some modern writers have listed exercises for the development of all the better recognized functions. Miss Morgan, for example, gives exercises, patterned somewhat after the psychologist's mental tests, for each of the following faculties: Sensation, perception, abstraction, association, attention, memory, imagination, invention, judgment and reasoning.[8] These exercises are devised for a class of children somewhat above the grade of feeble-minded, including both the dull and the backward.

For the light it throws upon the idea of training functions rather than the imparting of knowledge, and consequently upon the main principles underlying the so-called physiological method as described by its exponents, it is worth while to note some of Morgan's methods. Automatic memory is trained by having the child make " lists of common things, like the furniture in the kitchen at home, or all the things one cooks with, or all the things he has in his desk at school, or, if he goes to a carpentry class, all the tools he uses." " Another way to train automatic memory is to have the child repeat a series of words, numbers, or nonsense syllables which the teacher says to him, gradually increasing the number." Voluntary memory is trained by the writing of original rhymes. As the child learns his own rhymes by heart, he memorizes others on similar subjects. Gradually the committing to memory of prose and verse may supplement the verse writing. Exercises for the imagination include retelling stories, illustrating stories by freehand drawing, and making up stories accompanying colored pictures. Invention is trained by picture puzzles involving the piecing together of fragments and by completion tests, like those described in a previous chapter, in which the missing words of a story must be supplied.

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[8] Morgan, "The Backward Child," 1914.

These methods of so-called physiological education are brilliantly summarized by Binet[9] under the heading of "Mental Orthopedics." The name is suggestive. As physical orthopedics corrects the position of a spinal vertebra which is out of place, so mental orthopedics corrects, cultivates and strengthens attention, memory, perception, judgment and will. By this art one seeks not to impart knowledge of facts and ideas to the children, but to develop their mental faculties.[10] Binet cites numerous exercises, some borrowed from Séguin. He follows Séguin's practice of requiring at intervals absolute quiet and immobility; he introduces tests of strength of grip and speed of tapping, in which the children are encouraged to rival each other; and he develops motor control by having the children carry cups of water from one table to another without spilling a drop. An exercise of attention and memory, which he emphasizes particularly, employs a very brief exposure of a large card on which a number of objects are represented. The pupil must try to grasp in his attention all the objects on the card, and then write their names from memory. A long series of such cards was carefully worked out, with a gradually increasing number of objects. This exercise closely corresponds to what the psychologist calls a test of the span of attention. Binet states that subnormal children trained on this test were able, with a five seconds' exposure, to note and hold in mind as many as nine objects, long enough to return to their seats and write out the names —a performance of which many a normal adult would be incapable.

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[9] "Les idées modernes sur les enfants," 1909, pp. 140–161.

[10] *Op. cit.*, p. 150.

Critical Estimate of the Physiological Method.—I have now described in sufficient detail the method of education termed physiological or orthopedic. I have tried to make clear that the main principle, in the accounts of those who have done most to perfect this method, is that education should deal with the training of mental functions. It clearly implies the existence of mental faculties or powers, and aims directly at the training of these powers.

Whatever the explanation, education based on this principle of formal exercise of fundamental functions has been successful. Its excellence is shown by results with feeble-minded children, from the time of Itard down to the present. Morgan, who discusses serenely the training in backward children of attention, of voluntary memory, and so forth, says that she gathered her material from an experimental clinic conducted for two years in New York City, in which children were tested for, and trained in, the particular deficiency revealed in them by examination. The brilliant results obtained by Montessori are known to all the world. Binet did not content himself with the testimony of teachers, but verified their reports of success with subnormal children by carefully devised mental and educational tests.[11] Binet became so enthusiastic as to believe that the method which formed the basis of the orthopedic method, so successful with the feeble-minded, was the proper one to use with normal children; he even went so far as to declare it to be the only method of genuine education.[12]

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[11] "Les idées modernes sur les enfants," 1909, pp. 144–146.

The success of the method must be admitted; but it is exceedingly doubtful whether its success is due to the fact that the exercises it employs are aimed directly at the development of the various mental faculties, as faculties, rather than at the imparting of particular bits of knowledge or special arts. It is likely that the authors of the method have misunderstood the reasons for its success. Let us consider, for example, some of Montessori's statements. She writes that "In a pedagogical method which is experimental the education of the senses must undoubtedly assume the greatest importance." This education of the senses, she says further, "makes men observers, and not only accomplishes the general work of adaptation to the present epoch of civilization, but also prepares them directly for practical life." These remarks are unsupported by any known facts. So far from being fundamental, keenness of the senses, as a previous chapter points out, plays a relatively unimportant part now in the determination of intelligent behavior. The correlations with intelligence shown by sensory keenness—that is, the ability to make fine sensory discriminations—are low. The correlation for tactual discrimination is practically zero, and for weight discrimination appears to be negative. No test of sensory discrimination has ever been demonstrated to give a correlation of over .50. Moreover, it should be understood that Montessori's methods have succeeded only with young children. No doubt, among the large assortment of general rules stated in Montessori's book, may be found some capable of use in the education of children at any age; but the body and substance of the Montessori method is the training of children between the ages of three and seven, the kindergarten ages. Now *during these ages,* it is true that training in sensory discrimination should occupy a very important place. It should do so, I would suggest, simply because at these early ages, the sensory capacities have reached a relatively advanced stage of growth. A child is not so far behind a man in sensory discrimination as in the ability to concentrate attention or to reason. In short, in devoting attention to the education of the senses of a young child, we are training him in the occupations for which, at the time, he is best equipped.

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[12] *Op. cit.*, p. 154.

The crucial explanation of the success of the so-called physiological or experimental method, then, is not the fact that it trains the mental and physiological functions, but that it is adapted to the capacities possessed by the child—that it exercises the innately strong capacities. From this point of view it is easy to understand the success with which Séguin's methods have met in the education of the feeble-minded. These children, like the normal children trained by Montessori, were for the most part between the mental ages of three and seven. At these ages, the sensory capacities have completed sufficient growth to be profitably trained. The capacity to make movements is also well developed. It is sensory training and motor training, consequently, that loom largest in education during the mental ages three to seven. Besides these, there is some training in memory work, particularly in rote memorizing. The memorizing capacity is usually good enough to justify more attention to its exercise than is customarily given. There is a prejudice against rote memory training, because it is so much less useful than training in judgment and reasoning. But feeble-minded and young normal children have little capacity for judgment and reasoning. Their most valuable asset is rote memory capacity. Its training should, therefore, form a conspicuous part in their education.

Experiments in the Education of Children with Exceptional Abilities.—It begins to be clear that the study of methods successful with backward and feeble-minded children may shed light upon the general problem of relating individual differences in intelligence to educational methods. The same principles apply to the education of exceptionally bright children as to that of the exceptionally dull; but these principles must be properly understood. The most important is that the methods employed must be suited to the child's capacities. These capacities are by no means the same in the bright child as in the dull or backward child. Methods which would be ridiculous when used with the latter may bring about brilliant results with the former. Some illustrations of carefully recorded cases will make this clear.

The education of a little girl who, at the age of twenty-six months, could read from any primer fluently, and with better expression than most first-grade children, has recently been described in detail by her father.[13] While the intelligence quotient of this youthful prodigy is not given, nor that of one of her brothers, it is stated that her oldest brother, aged eleven, has an intelligence quotient of 1.7, the highest quotient which Terman, who communicates the case, has ever discovered among California children. As one studies the methods which produced such wonderful results, one cannot help but realize that their success must have been due to aptitudes very exceptional in a child of such an early age. Among the capacities unusually advanced in growth were the instinct of curiosity, the powers of memory and attention, and the desire for approbation.

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[13] "An Experiment in Infant Education." *Journal of Applied Psychology,* Vol. II, 1918, pp. 219–228.

The following method, used to teach the capital letters, clearly indicates interests far stronger than in the average child. "I placed in her hands a book," writes her father, "which, in addition to a number of pictures interesting to the child mind, contained capital letters in flaring type and colors. She at once became interested in the pictures and fell into the habit of rushing to me whenever I entered the house, to have me show them to her. At these times I took her on my lap, turned to a picture, told her what the objects represented were, and chatted about them in such fashion as seemed most to arouse her interest. Occasionally I turned suddenly to the pages of capital letters, pointed to one of them, and exclaimed with feigned excitement, 'Oh, Martha! Look! Look! There's P!' Then, without giving her time to discover the deceit and to determine for herself that after all there is nothing wildly exciting about the letter *P*, I returned to the pictures and excited her interest in the vicissitudes of Tom the Piper's son, only to turn back after a few moments and point with an exclamation to another letter. The pictures were unquestionably of great interest to her, and as the references to the uninteresting capitals were only occasional and momentary, the net result of these sessions was that she found the book as a whole a great joy, failed to discover the camouflage in the matter of the letters, and nevertheless became familiar with them. When she was nineteen months and thirteen days old she was able to recognize and pronounce all of the capital letters."

Even more interesting is the method used in teaching the small letters. "I drew the letters carefully on the back of business cards, and kept a few of these in my pockets. When she grew tired of looking at pictures I allowed her to play with these cards, of course calling her attention from time to time to the letter on the back of each. She became interested about this time in exploring my coat pockets and pulling the contents out of them, so I sometimes placed a few cards in a pocket open to attack, and allowed her to pull them out one at a time, refusing to let her have a card until she pronounced the letter on the one already pulled out. As this refusal constituted an obstacle to an interesting investigation, she sensibly surmounted it by observing the letters and pronouncing them in order to experience the joy of delving into the depths of the pocket for a new card. At other times I varied the play by sitting down with a pack of the cards in my hand and giving them to her one at a time to be carried by her across the room and delivered to her mother or aunt, refusing to give her another until she told mother or aunt the name of the letter on each card delivered. Both mother and aunt always displayed a highly gratifying interest and astonishment at all information so volunteered by her, and she doubtless felt that she was playing a very important rôle in an extremely important matter. At any rate she enjoyed the process immensely and incidentally learned her small letters."

The above methods, it is true, are simply ingenious applications of the fundamental principle of all teaching, which is to link the thing which the child is to learn with activities in which he is already interested and which he naturally enjoys. The wonderful success of these methods, however, can be explained only on the postulate of very exceptional capacities on the part of the child, and the whole experiment is merely an illustration of what special methods may accomplish when directed towards the training of special capacities.

Exceptional mental attainments cannot be produced by any educational methods unless exceptional ability of some sort exists in the child. On the other hand, when superior abilities are present, no formal methods need to be used. The main thing necessary is to provide opportunity for the child to exercise these abilities freely and spontaneously. The child needs to be studied and intelligently guided, but will learn naturally and without fixed lessons or tedious drill. This naturalness of learning when unusual talent is given plenty of opportunity for its exercise is strikingly illustrated in the development of Winifred Sackville Stoner, Jr. The following extracts are taken from an account of her education written by her mother, when the child was twelve years old.

" Winifred has no set lessons, but from early training she has become such a lover of good literature that she would be most unhappy if deprived for a single day of converse with her book companions. She reads at least for an hour each day. At present she is reading everything she can find about Japan, as she plans to write a play on this subject. For two hours she helps me as my secretary, answering letters, and working on ' The Natural Educational Manual ' and ' Natural Educational Game Book,' two books to be ready in fall. Winifred and I will be joint authors of these books, and another book belonging solely to the kiddie, and which she calls ' Facts in Jingles,' will be published by Bobbs-Merrill in a few weeks. Winifred has corrected proof of this book since returning from New York.

" She practices for perhaps an hour each day on both her violin and piano, and amuses herself playing for little colored children who live in cabins facing our reservation, playing for them on the mandolin, jew's-harp, or orchestra bells.

" One or two afternoons of each week she goes to the beach to swim, and on Wednesday evening she is allowed to attend a little dancing club until 9.30 P.M.

" Nearly every pleasant Saturday afternoon she goes with several friends of her age canoeing or botanizing. As you know, North Carolina is the home of some very interesting plants, among them the Venus fly-trap, bladderwort, pitcher-plant, and other carnivorous members of the plant family. Winifred is intensely interested in these plants, and has sent specimens to a number of our friends in northern cities.

" Each morning she plays at least one game of tennis before breakfast, and after dinner in the evening she and I play croquet or take long walks through the white sandy tracts around our home.

" At least fifteen minutes is spent in the kitchen each day gaining knowledge of culinary matters, and yesterday Winifred made a skirt for herself.

" On one of our up-stairs porches I have a regular gymnasium, and here every afternoon, when we are at home, we exercise for at least one-half hour before taking a shower-bath and rub-down.

" The little girl has learned how to drive an automobile, and occasionally I let her drive when we take motor-trips. She drives also her horse Coupon, and occasionally rides horseback. . . .

"Winifred has a canary which she has tamed and taught to do many wonderful tricks, and while she writes her stories on the typewriter he sits on the carriage of the machine and sings to her. To-morrow she is to receive a monkey and poll-parrot from a sea-captain, and then you will believe that there will be no time for study of books, as the pets will take up every spare moment.

"I am writing to you of these trivial matters so as to paint a picture of the simple, happy, full life Winifred leads at this chrysalis time of life, when no child must be forced to study or to play."[14]

Winifred Stoner at six months could talk; at eighteen months, read; and at five years, speak eight languages. She has specialized in music, art and eurhythmic dancing. She is said to be a perfect specimen of physical health and strength, and to be altogether free from conceit.

There are a number of types of supernormal children. Some are merely precocious, that is, growing at an exceptionally rapid rate; when grown up, they may not be especially intelligent, but they mature early. Others, who may grow either fast or slowly, have a really superior mental endowment. This superiority may be quite general, and apply to the great bulk of their mental faculties. In other cases, while the general level of the mental capacities may be above normal, only one or a very few of these capacities may be strikingly superior. Of course no child is equally developed in all of his capacities. One capacity may be very superior while the others may be only slightly so, or even mediocre. The superior capacities of exceptional children of this latter type may be easily overlooked by the teacher. Indeed, it is frequently alleged that some of the great men of history, who did poorly in school work, were men of one-sided development, whose valuable traits were not appreciated by their school teachers, but were given opportunity for their development outside of school.

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[14] Groszmann, "The Exceptional Child," 1917, pp. 108–111.

The education of children who show only a one-sided exceptional capacity should take its cue from their specialties. Naturally we should desire to prevent a one-sided development, and to produce a child of well-balanced character and intellect. This cannot be done, however, by ignoring the child's special aptitude and attempting to educate him along lines unrelated to his specialty. If we try this, we shall simply find him a stupid child. It is necessary to make use of the special talent, to use it and the interests related to it as a starting point, as a base from which to conduct our entire educational campaign, extending into all the fields of learning.

A very good illustration of supernormal ability, in which one trait in particular stood out above all others, is afforded by one of the boys trained in the laboratory school of the National Association for the Study and Education of Exceptional Children in Plainfield, New Jersey. This boy, thirteen years of age, was of a decidedly inquisitive type, and possessed to a high degree initiative and the tendency to original experimentation. This highly desirable side of his character was in danger of being suppressed by his teachers because coupled with mischievous tendencies. He " built fires in the cellar of his home, not from viciousness, but because he wanted to see what would happen. He played innumerable pranks on his schoolmates and teachers, who did not understand him, so that he was constantly in mischief and upset all discipline." Taken into the laboratory school, however, " his inquisitive tendency was made use of through experimental studies of all kinds, in the science laboratory, in the workshop, in road and building construction and in many other ways. He was given opportunity to apply his great energy in numerous outdoor games and sports, playing Indian, building wigwams, camp-fires, etc. His book-studies were carefully coördinated with this life activity."[15] The effect of this treatment was to change his entire mental and emotional attitude, and after leaving the laboratory school, he was reported as standing at the head of his classes in select private schools.

Sometimes a high order of intelligence is accompanied by defects which make it imperative to base education upon the use of the stronger faculties. A striking instance is described in detail by Bronner. "We know," she writes, "of a boy now 14 years old whose entire school career has undoubtedly been greatly modified for the better because his intelligent parents understood better than his teachers the harm that was resulting from the use of methods not adapted to his defective functioning in certain mental processes. It was early recognized that the boy had poor auditory powers and exceptionally good visual powers. When five years old he drew a very good representation of the façade of an ancient university building he had seen, and at seven made a most complicated drawing of a quadruple expansion waterworks engine. Though a great effort was made from the time he was a year old or so to teach him Mother-Goose rhymes and other couplets, he never recited correctly the simplest verse until he was six years old; nor has he ever been able to carry a tune correctly or sing a song, in spite of intensive and oft-repeated attempts to teach him simple music. It is interesting to note, for instance, that ' America ' has been sung and played to him hundreds of times and even played by him without his acquiring the ability to sing it.

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[15] Groszmann, *op. cit.*, p. 121.

" At five years of age this boy was sent to a fine private school where the teaching in the first grades was largely oral. When in the third grade he was placed in a subclass for backward children because he was so retarded in number work. Though the boy made no progress in music nor in memorizing verses, this was not interpreted as of any significance, nor was any effort made to utilize his good visual powers in place of his defective powers of audition. When, however, his parents were told (by an unusually competent teacher) that the boy was not learning arithmetic and was probably defective in this type of work, they themselves began to teach him by visual presentations. In two weeks he had not only mastered the work assigned the grade, but led his class. In the next two years, acquiring the power to learn by visualization, he accomplished the ordinary work of four school grades. . . . His powers of perceiving logical relationships are extremely good, and these, together with his quite unusual visual gifts, enable him to maintain class standings considerably in advance of his years." [16]

The preceding concrete examples suggest several practical conclusions. One important point is that we must make a more systematic effort to discover unusual gifts or unusual abilities about which to focus a training that will lead to the most useful development. Educational efforts must be devoted to bringing out at each period of his life the best there is in the child. In this connection

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[16] " The Psychology of Special Abilities and Disabilities." 1917, pp. 222–224.

I have been greatly interested in the very successful experiment being carried on in a large school system in a neighboring city, with children of superior brightness. By means of intelligence tests, those children are selected whose mental ages indicate that they ought to be doing more advanced school work. These children are then given further mental examinations and individual study by a special teacher, who aims to discover their leading aptitudes and interests, to create more favorable mental attitudes on the part of the children towards their work and their teachers, and finally to prepare them for a trial in the higher grades which accord with their advanced mental ages. I am informed that the great majority of these children are now doing better work in the grades to which they have been advanced than in the grades in which they were originally discovered.

A word of caution must be added. I have said that a more systematic effort should be made to discover special abilities and special interests—in both dull and superior children—and that the training given children should afford opportunity for the development of these exceptional capacities. This does not mean, however, that we should determine in which one of his mental faculties a child is strongest, and then devise formal exercises for the development of this faculty to the exclusion of the rest. The ideal is to train all his really valuable capacities so that they may obtain their greatest usefulness. The development of intellect and character must be as many-sided as is consistent with a proper balance between time, energy and cost on the one hand and the results that are likely to be achieved on the other. But whatever capacity we are trying to train or whatever art or knowledge we are trying to impart, we shall succeed best by beginning where the child is strong and working out gradually into regions where he is weak, by organizing our endeavors as much as possible into a related system in which the fundamental appeal is to the child's natural aptitudes. Only in this way can we get out of the child his greatest effort, the limit of hard work and drudgery of which he is capable, and the development of a strong character.

The Training of Mental Capacities.—It remains to consider what it means to train a capacity. In general, it may be said that training cannot increase the fundamental capacities, but simply teaches the child to make the best use of such capacities as he possesses. This training may consist in the formation of very general habits, such as habits of concentration of attention and the most efficient methods of study, or it may consist in specific information, such as the multiplication table. In teaching the child the more general habits, formal exercises may be used. These formal exercises, like the exercises for training the senses, which are so prominent in the physiological method, often seem to be aimed at the development of faculties as such. In reality, however, they consist simply in drill for the formation of habits which are useful in a very wide range of situations. To train a child's capacities, then, does not mean to give him *more* memory, *more* attention, or *more* reasoning power, but rather to lead him to memorize that which is most useful, to attend to those things which are most worth while, and to reason out problems of ever-increasing weight.

Let us consider somewhat more in detail the training of a mental capacity—for instance, the capacity for attention. *Capacity* for attention, like that of intelligence, is determined mainly by heredity, environment before the age of school, and by growth. As a general power of the mind, a general capacity or faculty, it is as little subject to increase by education or to improvement by training as is general intelligence.[17] Therefore, all that training of attention really means is that, by a change in the conditions under which attention is given, and by a reduction, through habit and familiarity, of obstacles to its application, there may be brought about, in many directions, a greater ease of mental concentration.

Before any change can be made in the conditions affecting attention, one must ascertain the nature of these conditions. There is, in the first place, a considerable variety of objects which secure the attention even when that capacity is very feeble indeed. Among these are loud sounds and bright lights, strong odors and severe pressure on the skin—in short, all very intense stimuli. The great attention value of intense stimuli is enhanced by the factors of suddenness or novelty and of movement or rapid changes of any sort. Sometimes, too, a stimulus which is not strong enough to attract attention upon its first occurrence will do so by dint of repetition. Attention to such stimuli represents the earliest stage, known as passive or spontaneous attention, and is said to be due to the "objective" conditions of attention.

In addition to things which provoke notice through the objective conditions, there are others which arouse interest because of their relation to instinctive tendencies. The most fundamental instinct is that of self-preservation. It is partly on account of this instinct that intense, sudden and changing stimuli have such a strong appeal. They are often dangerous. But even when the object is not intrinsically of the sort to attract attention, it will do so if it is fitted to bring out some instinctive tendency—for example, that of self-preservation. That this tendency is recognized and accepted as an important factor in attention is seen in its application, by the ingenious primary teacher, to reading lessons. The teacher draws on the blackboard a picture of a house, and fills the interior space with common words, each of which represents one of the children in her class. She then tells the children that someone has set fire to the building and that only those can be saved whose names are read. When a child reads a word it is erased and thus in imagination they rescue themselves from the flames. So interested do the children become in preserving their "lives," that they learn unfamiliar words with renewed interest and increased attention. Again, an object which may satisfy hunger will attract the attention even of an idiot. Thus the savage of the Aveyron, though insensible to the loudest noises—he seemed not to notice a pistol shot—could nevertheless hear the fall of a nut!

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[17] Woodrow, "The Measurement of Attention." *Psychological Monographs,* 1914, No. 76, p. 141.

There are many other instincts than that of self-preservation which promote attention to the objects with which they are concerned. It is impossible to give a complete list of them, because their expression is so indefinite and so quickly modified by learning. Among the more obvious ones are fear, anger, love and affection, sociability and sympathy, desire for approbation, rivalry, fighting, loyalty, imitation, all the numerous forms of play and gaming, curiosity, collecting and constructive tendencies, hunting and roaming, and the regulative instincts of morality and religion.[18] In general, whenever an interest is shown naturally by many children, we may be sure that it is a tendency at basis instinctive, that is, one which does not need to be learned, but occurs spontaneously on account of the inherited disposition of the nervous system. Each instinct involves an action, or general line of conduct, of a sort to satisfy some want or need. It is a response made to some stimulus, some object or situation which attracts attention in a powerful manner without any effort on the part of the subject. The appeal to the child's attention exerted by the primary or original excitants of an instinct is rapidly extended to everything in any way associated with these originally interesting objects, as well as to all the means for successfully carrying out the instinctive activities.

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[18] See Kirkpatrick, "Fundamentals of Child Study," 1917, chapters iv–xiii.

Spontaneous attention, caused by the sheer intensity, or force, of the external stimuli which excite the senses, and instinctive attention, brought about by the direct appeal to instincts, are hardly above the animal level. In all normal persons there develops from these a higher attention, embracing matters only indirectly connected with the satisfaction of wants. This sort of attention is called out when the child meets with some obstacle to the immediate carrying out of an instinctive response. A problem which at first protrudes itself upon his attention because of its instinctive interest for him later acquires a new and higher interest through the mere fact that it has already attracted attention. For it is a fundamental law that a certain familiarity with an object or situation, knowledge about it or past experience with it makes it interesting and easy to attend to. Thus new interests are derived from instinctive interests, which in turn develop still others, until we finally reach the highest stage, that of sustained attention to abstract problems.

There is no more fascinating nor valuable study for the teacher than that of development in her pupils of one interest upon the basis of another. She may observe, for example, that at first the instinctive desire of approbation from his teacher, as well as fear of her, may lead a child to follow directions. In doing so, he meets with difficulties which hold his attention simply because the teacher is over him, but which, provided the tasks imposed are closely related to instinctive activities, may in time become interesting of themselves. Through working with arithmetic problems bearing upon the construction of kites, or upon the playing of store, the child may acquire an interest in arithmetic for itself, independent both of its connection with his pastimes and of his desire to please his teacher. Having acquired an interest in arithmetic problems, he may, in turn acquire an interest in the higher branches of mathematics, partly because in them he meets with items with which he is already familiar, and partly because he needs these higher branches in solving the arithmetical problem in which he has now become interested.

The preceding hasty sketch of the various types of conditions which call out attention should suggest an understanding of what is involved in the training of attention. This, as I have stated, does not mean increasing the fundamental power, but merely directing its application to the loftiest and most profitable topics.

In children of the lowest level of brightness, the idiots, even the power of spontaneous and instinctive attention is very feeble. Many instincts are lacking, the only one approaching dependability being the instinct to satisfy hunger. Children with attention of this sort have to be trained, like animals, through reward by food. Even food, however, will not hold their attention for any length of time; for at each distraction their attention is diverted from its original object and does not return. All that can be accomplished with these children is to teach them to feed themselves and to keep themselves clean; their power of attention is not great enough for the accomplishment of more complicated tasks.

In the higher degrees of feeble-mindedness and in dull children, the power of attention has greater strength. It cannot be trained, however, for long occupation with non-instinctive activities. It is hopeless to expect these children ever to devote themselves assiduously to book learning or to abstract ideas. Their education must be primarily through play and games and limited to those concrete activities—responses to real objects rather than printed symbols—in which the instincts naturally and with little modification manifest themselves. Even under these favorable conditions, short periods of exertion, say of half an hour or an hour, must be followed by a rest.

Play, it is true, is a great educational factor in the life of any child, whatever his age or brightness. Games and playful occupations suited to children of every age exist in great number, and much care has been expended in developing their educational possibilities. Entire courses of education by means of play-schools have been worked out and put into successful operation. It is with children of the lower mental ages, however, that the use of play and games is particularly indispensable. Their feeble attentions require constantly the support of the interest accompanying pleasurable activity.

In addition to definite games, there are innumerable playful activities which have especially great educational value. Among these may be mentioned the following: Collections (minerals, stamps, coins); cooking, particularly for girls; drawing; field work (study of butterflies, birds, fishes, flowers and ferns); flower and vegetable gardening; mechanics, such as the making and sailing of boats, putting together various kinds of machinery and making toys; dancing and dramatics; music (singing, orchestra and piano); photography; sloyd (basketry, cardboard and paper work and wood work); and printing.[19] Of all these activities perhaps none has such a wide appeal as dramatics. The dramatic instinct, whether expressing itself in the playing of Indian or Eskimo or in the production of a Shakesperian tragedy, is a force, which, if given opportunity for its development, is of invaluable help in the teaching of language, of manners, of decoration and mechanical construction and of sewing and costuming, and lastly, in the implanting of noble and influential thoughts which will inspire and elevate throughout a life-time.

With young normal children and with dull or feeble-minded children of any age, it is imperative to make a careful forecast of the maximal attainments of attention, and then to plan out a method of linking these attainments as closely as possible with the most free and natural expression of the child's instincts. At every stage, it should be made certain that there exists a strong appeal to a natural tendency to action on the part of the child, for otherwise he cannot be expected to persist in his efforts to the neglect of the slightest distraction. With these children, the difference between a wise educational method and a foolish one is that the former endeavors to lead the child's attention to simple, useful occupations instead of attempting to direct it upon book learning.

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[19] For details concerning the educational use of these activities, see Johnson, "Education by Plays and Games," 1907, pp. 51–64. See also Hetherington, "The Demonstration Play School of 1913," *University of California Publications, Education,* Vol. V, No. 2.

With normal children, the ordinary school subjects, which have been selected through generations of experience, offer excellent training of attention. They provide topics of interest, of a gradually increasing complexity, and as items of information, possess a degree of importance difficult of exaggeration. The main need here is a more careful consideration of individual interests. The most effective leading of attention can be secured only by utilization of individual tendencies and interests, whether instinctive or acquired. The thing upon which it is desired to have the child concentrate must be connected with his individual interests—not simply with those of children as an abstract class of beings. In the words of McMurry, " Each study must be intimately related to the pupil—to each pupil, just as far as possible. It is expected to appeal to his ambition and establish purposes within him; to give him practice in judging the relative values of facts as they bear on these purposes, which would be impossible if he sensed little value in the projects or purposes themselves; to lead him likewise to organize data, use knowledge frequently, and do all these things largely on his own initiative and in an independent way." [20] To thus vitalize a study for the pupil and at the same time to connect it with the life of society in general, McMurry reminds us of the value of live, interesting questions. " The idea is that a study is ideally a sum of live questions, alive both to the adult and to the child; and that a good course of study in any branch of knowledge is a sum of such problems along one great line of interest, organized in good sequence and containing data enough to furnish satisfactory answers to the problems." The setting of interesting questions is certainly one of the most fundamental ways of securing attention. As one high authority writes in a discussion of how to secure attention, "Man is blind to what does not correspond to his momentary purpose." The purpose may be aroused, this authority continues, by a question asked by another, or by some task that has been set, or problem that has been raised.[21] McMurry gives the following questions as illustrations of questions which are both interesting to the pupil and related to social life:[22]

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[20] " The Uniform Curriculum With Uniform Examinations." *Journal of Proceedings and Addresses of the National Education Association,* 1913, p. 135.

In Physiology and Hygiene:

What are the uses of food in the body?

How keep the digestive organs in health?

How care for the teeth?

How take care of the nervous system?

In Arithmetic, in the early primary grades:

How read the street numbers, and house numbers about us?

How use money for travel on street cars?

What quantities of milk and cream are commonly bought? Make out bills for given amounts.

How keep score for the game of bean bag, dominoes, etc.? Make out such scores.

In History:

What has been our treatment of the Indians; and what seems to be our plan in regard to them in the future?

On what occasions has the union of our states been threatened; and is it now permanently established?

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[21] Pillsbury, "The Fundamentals of Psychology," 1916, p. 254.

[22] *Op. cit.*, pp. 135–136.

In exceptionally bright children, one may confidently expect that, long before its growth is completed, the capacity for attention will become sufficiently powerful for sustained study of difficult subjects. The natural curiosity and ambition of such children lead them of their own initiative to undertake tasks to which the attention of normal children can scarcely be held by all the artifices of the expert teacher. Such children—often neglecting the humdrum routine of their regular classes—follow out elaborate courses of study in foreign history, in literature, in mechanical construction and in the scientific study of plants and animals and of rocks. With these children, then, above all others, pains should be taken to encourage the use of initiative—that great quality upon which depends true leadership, research and discovery, and consequently the progress of humanity at large.

Especial care should be taken, also, to develop the sense of duty and of responsibility to others. One of the most crying needs of society to-day is that the possessors of superior intellects should enlist in public service instead of engaging solely in their own selfish advancement. Not only in superior children, but in all children, to inculcate a sense of the individual's duty to society, to impart those ideals and habits which characterize the desirable citizen, should be a fundamental aim of education. But this development of the social sense is particularly important in the exceptionally bright child. He is the one who, when grown up, will have by far the greatest surplus of ability beyond the needs of his own support, the one who will be best able to serve society; and yet, just because of the ease of his success, he is the one in whom the sense of duty and responsibility is least likely to be developed by the ordinary school curriculum.

That the appeal of social service is capable of exercising a powerful influence on children of superior ability is vividly illustrated by an instance that came to my notice while carrying on an investigation in one of the Minneapolis public school classes. There was one boy in this class who had been advanced from the preceding grade because of a superior intelligence quotient. He had done only average work in his old grade, and when promoted, promptly settled down to the same mediocre position in the more advanced grade. One day, after recess, this boy came in and found the children who sat in the same row of desks as he did complaining to the teacher because their row didn't get more of the stars given as rewards. The teacher turned to the boy as he came in, and said, "Do you know what they are saying about you?" When he replied with surprise in the negative, the teacher explained that the other children were blaming him, claiming they didn't get the stars because he wouldn't work. The other children joined in a chorus, "It's all your fault." The boy turned perfectly white; it was clear that he was strongly affected. Before this time, he had not wanted to succeed; but henceforth he felt that he was working for the group and not for himself; and under this new stimulus he secured almost uniformly a grade of one hundred per cent., and at the end of the year ranked at the top of his class. This incident illustrates the effectiveness of social pressure as an incentive to persistent attention and work.

The principles of education of attention apply to the education of other mental capacities. The aim is not to increase the amount of any capacity, but to lead the child to make the best possible use of it. In regard to memory, William James has never been proven wrong. "No amount of culture," he wrote, "would seem capable of modifying a man's *general* retentiveness. This is a physiological quality, given once for all with his organization, and which he can never hope to change." [23] "All improvement of memory consists, then, in the improvement of one's habitual methods of recording facts." [24] It is true that the observations on which James based his conclusions were faulty. He conducted experiments indicating that practice in memorizing one kind of material does not improve one's speed in memorizing material of a different sort. They have since been repeated under more exact conditions, and it is to-day well established that practice with one kind of material aids in the memorizing of all kinds of material in any way similar to that used in practice. But this transference of training is due to an acquisition of correct technique of memorizing, or else to identical elements in the different kinds of material; and while improvement in the technique of study is highly valuable, it consists in a formation of habits which is within the capacity of persons of either good or bad memory, and which *aid* rather than *increase* this capacity.

The education of powers of judgment and reason is bound up with that of memory and attention. The child may be taught the technique of reasoning and led to apply his powers in this respect to problems lying in many useful fields of human endeavor. He may be encouraged to exercise his powers, and given the chance to acquire the knowledge upon which the success of their exercise is dependent. The first stage in the training of reasoning plainly is the provision of a wide experience extending beyond the class-room and embracing first-hand observation, so that the child may acquire a considerable knowledge of facts; for one cannot reason without facts. In higher stages, the child's attention may be directed to problems which lie in those fields of his own experience most likely to prove of value in later years. Here he requires help and encouragement, particularly in the matter of learning to test the correctness of his solutions by experiment.

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[23] "Principles of Psychology," Vol. I, 1890, p. 663.

[24] *Op. cit.*, p. 667.

The capacity for emotion is clearly either strong or weak in spite of education. No education can make a phlegmatic person emotional nor an emotional person phlegmatic. The educational problem is to effect an association of the individual's natural emotional responses with the right situations. We cannot change the *amount* of elation of a child at success, but we can constrain him to give vent to this emotion only at the right kind of success. We can create new desires and destroy old fears. The proper treatment of fears and desires, said to be the two greatest motive forces of mankind, is one of the most difficult and misunderstood, and, at the same time, one of the most fundamental, of all the problems of teaching. The emotion of fear in a child may be so strong and so easily aroused that it will completely stultify his mental development. A remarkable case has recently been described by Witmer, a pioneer in the psychological study of subnormal children, and an expert in their training, in which, apparently, a state not far from feeble-mindedness was due primarily to excessive fears, leading to an ostrich-like inattention to every new thing or person. Once these fears were overcome, the development of the child's decided positive abilities proceeded with amazing rapidity.[25]

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[25] "What I Did With Don." *Ladies' Home Journal,* April, 1919, p. 51.

Education must accept the capacities of a child as it finds them, and, by affording them every exercise possible, make them fit to render their greatest service. This does not necessarily mean that there is no value in formal exercises designed to develop this or that mental function. Memory lessons, attention lessons, and reasoning lessons have their use. They provide a mental technique, methods of mental procedure, which may prove useful in an endless variety of situations. Very likely it would be wise to provide formal "reasoning training" for exceptionally bright children at the higher mental ages, just as we provide sensory and motor training for children of the lower mental ages. Such exercises could be patterned after the tests I have described in a previous chapter as tests of logical-mindedness—tests involving the ability to pick out from a number of reasons the best one in support of a given statement, or to select the best conclusion from a number given as following certain specified premises; tests requiring the formation of a principle; tests of analysis and synthesis, involving the process of pointing out likenesses and differences, and exercises in the formulation of definitions and the recognition of absurdities. The possible value of reasoning lessons, imagination lessons, morality lessons, and so on, needs further study. Such lessons might form a valuable supplement to reading lessons, history lessons and arithmetic lessons.

By adapting our methods to the capacities of the child, by basing education upon an inventory of these capacities, we immediately become aware of numerous consequences of the greatest aid to our educational efforts. We find that we are providing exercises in which the child shows interest; that we are asking him to do things which he enjoys doing, because in their accomplishment he experiences the best success of which he is capable; that, because the appeal is to his natural interests, the child is willing to persist in his efforts in spite of fatigue and hardship. Of course, the teacher is never relieved from the necessity of broadening the child's interests, by associating them with allied interests; nor from the necessity of the judicial use of all the incentives to work which she commands, whether these be such natural ones as rivalry, curiosity and the inherent rewards of success, or such artificial ones as prizes and special privileges; but she will find that she is working with the child instead of against him. Spontaneity and enthusiasm will be displayed by the pupil, so that the teacher may be transformed from a tiresome drillmaster into a guide to the child's best development.

From the point of view of society, each child will be trained to his maximal usefulness, and prepared to fit into his proper place in the social organization. Social solidarity, the subordination of the individual to society, is not to be attained by attempting to make everyone alike. The unity of society is, and must be, that of a complex structure, not that of a sand-like, homogeneous mass. Consequently, by adapting our educational methods in the case of each child to his capacity for serving society, we pursue the course best calculated to preserve the integrity of the social organism, and at the same time best designed to develop that spirit of which democracies are so justly proud, the spirit of individual initiative and resourcefulness.

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